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THE OIL PALM (ELAEIS GUINEENSIS) AT CALABAR.

BY

E. H. G. SMITH, M.A.

Calabar, an important commercial centre and port, is situated on the Cross river, in the south-east corner of Nigeria, close to the mandated Cameroons. The climatic conditions are well suited to the oil palm; the rainfall is heavy and well distributed with an average, according to the Nigerian Handbook, of 112 inches per annum over a period of eighteen years. An Agricultural station was opened at Calabar about 1910, and early in 1923, this station was transferred to Umuahia situated on the recently built Eastern Railway. The plantation plots of the Oil Palm, (Elaeis Guineensis-Jacq.) that are described in the present paper, were established shortly after the opening of the Calabar station. These are the only plantation palms the department possesses, which were established prior to the disorganisation caused by the war and which are growing in typical oil palm country. Unfortunately, Calabar occupies a rather isolated position. Means of communication with the rest of Nigeria are poor and particularly so with the Western Provinces, where the laboratory at Ibadan is situated.

The work described in the present paper may be conveniently divided into three parts. Firstly, a description of the actual plantation plots and palms; secondly, an analysis of some of the yields obtained; and thirdly, an account of the selection work that has been commenced.

PART I.

OIL PALM PLOTS.

The keeping of individual tree records was only commenced in 1922, by which time some of the plots had been planted up for nine, and others for seven years. When the Agricultural station was transferred to Umuahia, these oil palm plots were retained, and have since been in the charge of a native assistant. Reference is made to the establishment of these plots in certain of the annual reports of the department (1). In establishing the plots, seed was chosen from four well-recognised types of the oil palm growing in the Eastern Provinces. Firstly, the ordinary thick-shell or hard type which is described under the Efik name of Okporo Eyop (thin fleshed palm tree); secondly, the ordinary thin-shell or soft type described under the Efik name of Osok Eyop (thick fleshed palm tree); thirdly, the form with the fruit surrounded by a ring of fleshy sterile carpels, Efik name Ayara Mbana Eyop (fruit surrounded by ring of spears palm tree); and fourthly, the form having fruits that are green in colour until ripening approaches, Efik name Afia Oku

Eyop (white medicine man palm tree). This latter type was confused at the time of sowing with the King Palm from which it is quite distinct. These types are described and their classification is discussed later.

PARTICULARS OF THE PLOTS.

In making the nurseries for these plots, seed was taken, except for the Osok (thin-shell type), from one parent tree only for each type. Naturally the plots have been supplied from time to time, but while it is believed that the seed was taken from the original parents up to about 1921, since that year it has probably come from a tree in the plot for which the supply was required. However, since 1921 very few supplies have been necessary. This supplying is known to have been heavy in plots 11 and 12. In the latter plot many of the palms date only from about 1920.

Particulars for each plot are as follows:—

Plot 4—Osok type (thin-shell).

This plot was planted up in August, 1912 with nursery seedlings obtained from two Osok parents, and fruiting commenced early in 1916. The area was planted at a triangular spacing of 20′ × 20′ and contains 268 trees. When checked, early in 1928, the trees were classed as follows:—

Okporo (thick-shell) type	186
Osok (thin-shell) type	66
Young, Non-fruiting or Dead	16
Total	268

Plot 6—Okporo type (thick-shell).

This plot was planted out at the same time as plot 4 with nursery seedlings obtained, it is believed, from an Okporo parent. Some confusion exists as this plot was called Osok in the early records, which appears to be an obvious mistake. The area is planted thirty feet square and contains 135 trees.

Examination early in 1928 gave:—

Okporo (thick-shell) type	125
Osok (thin-shell) type	8
Young or Blank	2
Total	135

Plot 10—Okporo type (thick-shell).

This plot was planted out during November, 1913, with seedlings obtained from an Okporo parent, while fruiting commenced

during 1916. It is believed that plot 6 was established with seed from the same parent tree. The area is planted twenty-five feet square and contains 243 trees. Examined as above the trees were classed :—

Okporo (thick-shell) type	221
Osok (thin-shell) type	17
Young or Blank	5
Total	243

Plot 11—Ayara Mbana (mantled) type.

This plot was planted out in September, 1915, but no yields were recorded until 1920. Nursery seedlings were used that had been obtained from an Ayara Mbana (mantled type) parent. The area is planted twenty-five feet square and contains eighty-four trees. No record was apparently kept of the shell thickness of the parent, but the numbers of the resulting different types of trees suggest that it probably was thin-shell. (This is discussed later). These trees were classed on examination :—

Ayara Mbana (mantled) thick-shell type	24
Ayara Mbana (mantled) thin-shell type	6
Okporo (thick-shell) type	35
Osok (thin-shell) type	10
Young, Undetermined or Blank	9
Total	84

Plot 12—Afia Oku (green fruited) type.

This plot was planted out at the same time as plot 11, with nursery seedlings obtained from an Afia Oku parent. The area is also planted twenty-five feet square and contains seventy-eight trees. It is also suggested that a thin-shell parent was used for this plot, but no record has been found. Many trees in this plot were planted about 1920 and a few more recently. Similarly, as with plot 11, the first yields were recorded in 1920, but both these plots may have yielded before. Examination of the trees resulted as follows :—

Afia Oku (green fruited) thick-shell type	19
Afia Oku (green fruited) thin-shell type	12
Okporo (thick-shell) type	30
Osok (thin-shell) type	10
Young or Undetermined	7
Total	78

Ratios of the different Types found.

Assuming that for each plot, all the trees classified were raised from a single parent (except for plot 4, where two similar parents were used)—an assumption which, for trees bearing fruit by early in 1928, is probably not very incorrect—the following interesting ratios between the different types and shell thicknesses in each plot are obtained:—

Plot.	Parent Tree.	Progeny produced.	Actual numbers.	Expectation based on ratio in last column.	Ratio.
4	Thin-shell ...	Thick-shell ...	186	189	3 : 1
		Thin-shell ...	66	63	
6	Thick-shell? ...	Thick-shell ...	125	124·7	15 : 1
		Thin-shell ...	8	8·3	
10	Thick-shell ...	Thick-shell ...	221	223·1	15 : 1
		Thin-shell ...	17	14·9	
11	Mantled... ... and	Mantled... ...	30	37·5	1 : 1
		Non-mantled ...	45	37·5	
	Thin-shell? ...	Thick-shell ...	59	56·25	3 : 1
		Thin-shell ...	16	18·75	
12	Green Fruited ... and	Green Fruited ...	31	35·5	1 : 1
		Non-green Fruited	40	35·5	
	Thin-shell? ...	Thick-shell ...	49	53·25	3 : 1
		Thin-shell ...	22	17·75	

Note.—All the proportions obtained in the above table are statistically significant.

Nothing can be done, at the present stage of our knowledge of the genetics of the oil palm, beyond pointing out these ratios which suggest, for the Calabar palms, that shell thickness is governed by at least two factors, and that the green-fruited and the mantled

forms are governed each by one. It is upon this suggestion that the opinion expressed earlier is based; namely, that the Afia Oku (green fruited) and the Ayara Mbana (mantled) parent trees were probably thin-shell. Deighton (2) has reported a much higher proportion of the thin-shell trees, raised from Nigerian seed of thin-shell type, than was obtained at Calabar (thick-shell to thin-shell 3 to 1 in plot 4), but this may be due to this seed being taken from thin-shell palms surrounded by an unusually high proportion of trees of the thin-shell type. On the other hand, the Calabar parent trees were wild palms and the expectation is that they would be pollinated by the thick-shell (Okporo type) trees, which are the predominant bush type—Farquhar (4). However, it is impossible to generalise on the material that is available and there are, most probably, other factors involved such as factors for size of fruit.

Intermediates in Type.

It will be noticed, that in none of the plots have any trees been classed as intermediate in type. Classification was based mainly on shell thickness and also on the presence or absence of the ring of coarse fibres, which was always found in the fruits of the thin-shell types and which is described later. It was possible by these means to classify the fruit of each of the Calabar trees as either definitely thick or thin shell. The observed variations that occur within each type, for size of fruit, mesocarp and shell thickness and kernel size, are probably due to the number of factors that appear to be responsible for fruit form.

Classification of Types.

1. *Okporo Eyop—(thick-shell palm).—*

This is the ordinary well-recognised thick-shell or hard-fruited palm and the vast majority of wild bush oil palms are similar to this type, Farquhar (4). Kew (3) classifies this as var. Angulosa Becc.; but it is probably synonymous with the local form called Akponojub, which has been described by Kew as var. Communis Chev. Becc. (lit. cit.). This type has been described by Farquhar (lit. cit.), in the Bulletins of the Imperial Institute (5 and 6) and in the Kew Bulletin (7). The average of this type probably lies between Yampolsky's var. Macrocarpa and var. Dura (8).

2. *Osok Eyop—(thin-shell palm).—*

Similarly, this is the ordinary thin-shell or soft-fruited palm, according to Kew (3) var. Ceredia Chev. and again it is suggested

that it is probably synonymous with the local form called Asogejub and described again by Kew as var. Communis forma Tenera (lit. cit.). Descriptions are given in the literature cited above. This type has a rather higher percentage of shell than Yampolsky's var. Tenera (lit. cit.).

3. *Afia Oku Eyop—(green-fruited palm).—*

This has been confused in some literature (lit. cit. 5, 6 and 7) with the King Palm var. Idolatrica, Chev. (3); but it is quite different, for the leaflets are free and not fused. Kew suggests (3 and 9) that it may belong to var. Communis, forma Leucocarpa. However, it comprises fruit of both the thick and thin-shell types, similar to Okporo and Osok respectively. Bücher and Fickendey (10) recognise and describe green fruited forms for the different shell thicknesses and also a mantled form of which no example was found at Calabar.

4. *Ayara Mbana Eyop—(mantled type).—*

This is the mantled form, Kew (3) var. Poissonii, Chev. and var. Diwakkawakka, Bücher and Fickendey (lit. cit.). The forms corresponding to both the thick and thin-shell types are recognised by Bücher and Fickendey, and Yampolsky (lit. cit.). A sample of this type is described in the Bulletin of the Imperial Institute (11).

Description of the Types.

Before proceeding to a description of each type in turn, it is well to note, that great variation exists within all types for size of fruit, mesocarp and shell thickness and for size of kernel. Further a proportion of unfertilised fruits are found in every bunch.

Okporo Eyop—(thick-shell type).—

Bunches are usually large but vary in size. Fruits vary in size both in the bunch and with different bunches from the same tree. Apical and external fruits are usually large and well formed. Shape varies with the number in each bunch and the degree of fertilisation; while generally pointed and angular, the fruits are sometimes almost eggshaped. The internal fruits are compressed and irregular, heartshaped to rectangular in form and often flattened. The colour is glossy black after fertilisation, a reddish tinge appearing as ripening progresses. When ripe the upper half is

glossy dark red and the lower half light red in varying proportions. Internal fruits are usually only dark red at the apex. The mesocarp is usually thin, in width generally less than that of the shell in cross-section. The colour varies from rich dark red (said to contain most oil) to light almost white tissue. There are no prominent coarse fibres. The shell of the nut is generally thick and hard. The kernel is usually large but varies in size. The number of kernels is variable, one is usual, two quite common, three rare and four very rare. In the typical Okporo fruit the shell in cross-section is twice the thickness of the mesocarp and the kernel is large. Forms are fairly common with mesocarp and shell of equal thickness and a good kernel, but with fruit usually smaller than the average. These appear to be similar to the published illustrations of the Deli type, Rutgers 8, but are mostly smaller in size. Another form, less common, has a fair mesocarp, a thick shell and a small kernel. A further form, of which a few examples were noticed, possesses large eggshaped brownish red fruits, with a good mesocarp equal to the shell in thickness and a large kernel.

Osok Eyop—(thin-shell type).—

The bunches and fruits are externally very similar, if not almost identical in appearance, to those of Okporo; but while some are as large, the majority are usually smaller in size. The most common form of fruit found is the glossy dark and light red form described for Okporo. The fruits are drawn out in appearance, and are rather more rounded than those of Okporo, with a small round nut set towards the apex. The larger fruits are rectangular in shape, with a considerable amount of solid mesocarp below the nut. The mesocarp is thick in cross-section and is at least twice, usually three and often four times the thickness of the shell. The colour varies as described for Okporo. A well-marked ring of coarse fibres, which varies in intensity, is situated in the mesocarp rather more than a third of the way through from the shell. The nut is small and the shell, which is usually thin and can be easily cracked, is variable in thickness. The kernel varies in size; but, while some are excellent in this respect, the true Osok kernel is undoubtedly small. Not more than two kernels have been observed in a nut.

Afia Oku Eyop (green-fruited type).—

This type resembles Okporo in that it has large bunches and fruits of good size. The fruits are much more rounded and egg-shaped in form than either those of Okporo or Osok. The colour

after fertilisation is a pale light green changing to a deep green as growth proceeds. As maturity approaches, the green gradually disappears from the base upwards and a light red colour appears until only a green tip remains. When fully ripe, all green colour has vanished and the fruits are an attractive light brick red. As is recognised by Bücher and Fickendey (lit. cit.), both thick and thin-shell forms are found in Afia Oku. There is little externally to distinguish these thick and thin-shell forms; in size of fruit they both resemble Okporo, there being little difference in this respect between them, in contrast to this difference between Osok and Okporo. The thin-shell fruits are rather more plump, while the thick-shell fruits tend to be slightly angular owing to the large nut. Internally the two forms of fruits are similar to Osok and Okporo respectively. The fibre ring described for Osok has always been found in the thin-shell form of Afia Oku.

Ayara Mbana Eyop—(mantled type).—

This type is easily distinguished by the mantle of sterile carpels (usually six) which surrounds the fruit. The development of this mantle is very variable with different trees; in some it almost encloses the fruit, in others it covers from a half to two-thirds, while an example has been observed where it is scarcely developed at all. Variation is also shown in the development of the mantle on fruits from the same bunch. The bunches appear to be smaller in size and do not contain the same number of fruits as the other types. The fruits are rounded in shape. When unripe, fruits vary from dull black to glossy black and on ripening a reddish tinge appears at the base moving upwards. When ripe the colour varies, and while the base of the fruit is usually a light red, the apex may be glossy dark red, an almost glossy black, or a brownish red in colour. Inside fruits are usually a light red. The flesh of the mantle and of the mesocarp varies in colour as described for Okporo. Yampolsky, Bücher and Fickendey (lit. cit.) recognise thick and thin-shell forms, both of which are found at Calabar. The shell of the thick-shell form is sometimes very thick and in both forms the kernels are usually smaller than those of Okporo and Osok respectively. The thin-shelled form is characterised by the ring of coarse fibres previously described.

No examples of the shell-less form—var. Glacilinux Chev. (3) and var. Pisifera Bücher and Fickendey (lit. cit.)—were found among the Calabar trees.

PART II.

Analysis of Yields.

It is to be regretted that so many of the Calabar palms, which provide the material for the present paper, are of the same Okporo (thick-shell) type. This naturally limits the information that can be obtained, from a study of the yields, of the relative values of each of these different types.

A summary showing the number of trees of each type in the different plots is given below :—

Type.	Number of each type in plots.					Total number of trees of each type at Calabar.
	4	6	10	11	12	
Okporo. Ordinary Thick-shell Type ...	186	125	221	35	30	597
Osok. Ordinary Thin-shell Type ...	66	8	17	10	10	111
Afia Oku. Green Fruited. Thick-shell Type	...	...	...	...	19	19
Afia Oku. Green Fruited. Thin-shell Type	...	...	...	...	12	12
Ayara Mbana. Mantled, Thick-shell Type ...	...	...	...	24	...	24
Ayara Mbana. Mantled, Thin-shell Type ...	...	...	...	6	...	6

From the above table it is seen that the number of trees of each type is small for calculating yields per acre, except for the Okporo (thick-shell) type in plots 4, 6 and 10, and for the Osok (thin-

shell) type in plot 4. The yields per acre obtained from the Plot 4 trees, which were very closely planted at a triangular spacing of twenty feet, are very low and are excluded from the present paper.

Data Available.

Reference has already been made to the fact that the keeping of individual tree yields was commenced only in 1922. Since then, figures for individual tree yields are available, with the exception of fruit weights during 1922 and 1923 for all plots, and also during 1925 for plot 10. Figures are also available for the results obtained from two extraction processes that were used over two periods. During the first period (extending from 1923 to mid 1926) a modified Native Washing process was employed to extract the mesocarp oil, while during the second period (extending from mid 1926 to mid 1928) the Cooker-Press Process—Barnes (13)—was used. These processes are briefly described later.

Presentation of the Data.

In giving the yields per acre, the actual acreage of each plot is disregarded and a proportionate figure for acreage is used, calculated from the spacing and from the number of trees for which yields are grouped. The areas allowed per tree for the two spacings, when calculating acreages, are as follows:—

Plot.	Spacing.	Area allowed per tree.
6	30′ × 30′	900 sq. ft.
10, 11 and 12	25′ × 25′	625 sq. ft.

Further, the young trees that have commenced to bear fruit since 1922 are excluded. Nearly all of these young trees occur in plots 11 and 12 and are the supplies mentioned when these plots were described.

In presenting the yields, two tables are given for each plot and are called table A. and table B. respectively. The yields for the different types of fruit in each plot are treated separately in these tables. Yields per annum are given for the Okporo (thick-shell type) trees in plots 6 and 10. Average yields only, over the period 1922 to 1928, are given for the rest of the groups, as the number of trees in each instance is so small.

Table A gives yields per plot and per tree and includes for the Okporo trees in plots 6 and 10:—

(1) Number, weight and average weight of bunches harvested per annum.

(2) Weight of fruit, average weight of fruit per bunch and the percentage of fruit weight to bunch weight per annum.

(3) Average number of bunches, average weight of bunches and average weight of fruits produced per tree per annum.

Table B gives yields per acre and includes for the Okporo trees of plots 6 and 10:—

(1) Number of bunches, weight of bunches and weight of fruit harvested per acre per annum.

(2) Weight of mesocarp oil obtainable by the Cooker-Press process, and weight of kernels produced per acre per annum.

The yields per acre of mesocarp oil and kernels given in Table B are calculated from the results given by the Cooker-Press process of extraction during the two years that this method was in operation at Calabar. Where possible these yields were calculated from the weights of fruit extracted, but all average yields (over the period 1922–1928) had to be obtained from the weights of bunches harvested.

Table I gives the results obtained from the two extraction processes.

Tables II and III give the frequency distributions of yields in lb. of bunches per annum for the Okporo (thick-shell type) trees in plots 6 and 10 respectively.

Plot Yields.

When comparing yields, it is convenient to take the plots in pairs. Plots 6 and 10 each contain a large number of Okporo, together with a few Osok trees. In plots 11 and 12, Okporo and Osok trees are found together with both thick and thin-shell Ayara Mbana (mantled type) and both thick and thin-shell Afia Oku (green fruited type) respectively. For each of the four plots the yields of the different types are given separately in Tables A and B as has been described.

Plots 6 and 10.

The yields of 125 Okporo and eight Osok trees are included for plot 6. The calculated acreages are:—

125 Okporo trees	...	...	2·583 acres.
8 Osok trees ...	...	...	0·165 „

The percentage yields of mesocarp oil and kernels (*see* Table I for percentages to fruits) used in compiling table B for this plot are:—

		Okporo trees.	Osok trees.
Mesocarp oil	—to fruits	17·6 *per cent.*	—
	—to bunches	11·3 „	14·1 *per cent.*
Kernels	—to fruits	10·0 „	—
	—to bunches	6·4 „	3·7 *per cent.*

For plot 10 the yields of 220 Okporo and seventeen Osok trees are grouped. The calculated acreages are:—

220 Okporo trees	...	...	3·156 acres.
17 Osok trees ...	...	...	0·244 „

The percentage yields of mesocarp oil and kernels (*see* Table I for percentages to fruits) used in compiling table B for plot 10 are:—

		Okporo trees.	Osok trees.
Mesocarp oil	—to fruits	17·8 *per cent.*	—
	—to buuches	11·4 „	14·3 *per cent.*
Kernels	—to fruits	10·8 „	—
	—to bunches	6·9 „	3·3 *per cent.*

Comparison between Yields recorded for Plots 6 and 10.

Plots 6 and 10 are suitable for comparison. Both these plots contain a large number of the Okporo and a few of the Osok type trees. Further, plot 6 is planted out at a spacing of thirty feet square, while the spacing of plot 10 is twenty-five feet square. These spacings give the following numbers of trees per acre:—

Plot 6—30 ft. square	...	...	48·4 trees per acre.
„ 10—25 ft. „	...	...	69·7 „ „

It must be noted, when comparing yields, that plot 6 was planted out over a year before plot 10 and that the soil of plot 10 is probably better than that of plot 6.

PLOT 6.—TABLES A. AND B.

Planted 30 feet square.

TABLE A.

125 Okporo (thick-shell) Trees.

1	2	3	4	5	6	7	8	9	10
Year.	Number of Bunches.	Weight of Bunches in lb.	Average weight per Bunch in lb.	Weight of Fruit in lb.	Average weight of Fruit per Bunch in lb.	Percentage Fruit weight to Bunch weight.	Average number of Bunches per Tree.	Average weight of Bunches per Tree in lb.	Average weight of Fruit per Tree in lb.
1922 ...	928	11,928	12·9	...	...	...	7·4	95·5	...
1923 ...	746	11,645	15·6	...	...	...	6·0	93	...
1924 ...	855	14,338	16·8	9,170	10·7	64	6·8	115	73·5
1925 ...	808	16,142	19·9	10,449	12·9	64·5	6·5	129	84·5
1926 ...	641	13,673	21·3	8,785	13·7	64	5·1	109·5	70·5
1927 ...	480	11,488	23·9	7,273	15·1	63·5	3·8	92	58
1928 ...	732	14,807	20·2	10,021	13·7	67·5	5·8	119	80
Average, 1922–28	741	13,432	18·1	9,140	13·0	65	5·9	107·5	73

8 Osok (thin-shell) Trees.

Average, 1922–28	40	643	16·1	352	8·8	56	5·0	80	44

TABLE B.

Okporo (thick-shell). Area = 2·583 Acres.

1	2	3	4	5	6	7
Year	Number of Years since Plot planted out.	Number of Bunches per Acre.	Weight of Bunches per Acre in lb.	Weight of Fruit per Acre in lb.	Weight of Mesocarp Oil per Acre in lb.	Weight of Kernels per Acre in lb.
1922	10	343	4,617	...	522	294
1923	11	289	4,507	...	509	288
1924	12	331	5,550	3,550	625	355
1925	13	313	6,248	4,045	712	404
1926	14	248	5,292	3,402	599	340
1927	15	186	4,447	2,816	496	282
1928	16	283	5,732	3,879	682	388
Average, 1922–28	10–16	287	5,199	3,538	587	333

Osok (thin-shell). Area = 0·165 Acres.

Average, 1922–28	10–16	242	3,897	2,133	549	144

PLOT 10.—TABLES A. AND B.

Planted 25 feet square.

TABLE A.

220 Okporo (thick-shell) Trees.

1	2	3	4	5	6	7	8	9	10
Year.	Number of Bunches.	Weight of Bunches in lb.	Average weight in lb.	Weight of Fruit in lb.	Average weight of Fruit per Bunch in lb.	Percentage Fruit weight to Bunch weight.	Average number of Bunches per Tree.	Average weight of Bunches per Tree in lb.	Average weight of Fruit per Tree in lb.
1922 ...	1,354	19,986	14·8	...	...	...	6·2	91	...
1923 ...	1,157	19,403	16·8	...	...	...	5·3	88	...
1924 ...	1,389	23,999	17·1	15,556	11·2	65	6·3	109	70·5
1925 ...	1,110	22,354	20·1	...	...	...	5·0	101·5	...
1926 ...	807	17,701	21·9	11,414	14·1	64·5	3·7	80·5	52
1927 ...	770	17,292	22·5	11,115	14·4	64	3·5	78·5	50.5
1928 ...	947	21,568	22·7	13,816	14·5	64	4·3	98	63
Average, 1922–28	1,076	20,329	18·9	12,975	13·3	64·5	4·9	92·5	59

17 Osok (thin-shell) Trees.

Average, 1922–28	81	1,443	17·8	796	11·1	54·9	4·8	85	47

TABLE B.

OKPORO (THICK-SHELL). AREA = 3·156 ACRES.

1	2	3	4	5	6	7
Year.	Number of years since Plot planted out.	Number of Bunches per Acre.	Weight of Bunches per Acre in lb.	Weight of Fruit per Acre in lb.	Weight of Mesocarp Oil per Acre in lb.	Weight of Kernels per Acre in lb.
1922	9	429	6,333	...	722	437
1923	10	367	6,147	...	701	424
1924	11	440	7,603	4,928	877	532
1925	12	352	7,082	...	807	489
1926	13	256	5,608	3,616	644	391
1927	14	244	5,478	3,521	627	380
1928	15	300	6,832	4,377	779	473
Average, 1922–28	9–15	341	6,441	4,111	734	445

OSOK (THIN-SHELL). AREA = 0·244 ACRES.

Average, 1922–28	9–15	332	5,913	3,262	845	195

OKPORO (THICK-SHELL TYPE) TREES.

From the tables A for plots 6 and 10 it is seen that no great differences are shown between the Okporo type trees of the two plots, in the figures for average weight per bunch, weight of fruit per bunch and for the percentage of fruit weight to bunch weight; but that the average yields per tree recorded for plot 6 are approximately twenty *per cent.* higher than the average yields per tree recorded for plot 10. This is less than half the increased average yield per tree for the more widely spaced plot 6, that is required to give

equal yields per acre for the two spacings. The average annual yields in lb. of fruit per tree for these two plots (plot 6=73 lb. and plot 10=59.1b.) are similar to the yields given for Africa by Annet and other writers and quoted by Rutgers (8).

While yearly fluctuations occur, it is seen that there is no marked change in the weight of bunches or fruit produced per tree or per acre after 1922, for although the bunches tend to decrease in numbers they increase in weight as the trees increase in age, and therefore produce approximately the same annual yield. That is to say two groups of Okporo (thick-shell type) plantation palms, growing at different spacings at Calabar, have reached their maximum yield by the ninth or tenth year after planting out and have maintained this yield, with normal seasonal variation, for (at time of writing) the next six years. Ives Henry's figures, given by Waters (12) for two plantations in Sumatra, suggest that the maximum production has, in these two instances, been reached about the same time. According to Annet, quoted by Rutgers (lit. cit.), maximum production is reached when the trees are twelve years old.

From the respective tables B, it is seen that the yields per acre recorded for plot 10 are approximately twenty *per cent.* higher than those recorded for plot 6. While yields from the two plots are not strictly comparable, this difference suggests that plot 6 is too widely spaced. This suggestion is supported by the fact that the leaves of the trees in this plot have not yet met to form a complete canopy. On the other hand it appears that the spacing of plot 10 (twenty-five feet square) is not an ideal one, as this plot contains a number of stunted, and a large proportion of low yielding trees (*see* Table III).

It is suggested that the optimum spacing for Calabar would be twenty-seven or twenty-eight feet square, giving 59·8 or 55·6 trees per acre. A greater number of trees per acre can be obtained by adopting a form of triangular spacing. Maas (8) advocates a spacing of nine metres square or triangular for Sumatra (equivalent approximately to 29·5 feet).

The yields of mesocarp oil per acre recorded for these Okporo trees, do not compare very favourably with Rutger's estimates for Sumatra (lit. cit.). Waters (lit. cit.) quotes Ives Henry's figures, which were obtained by the latter writer during a visit to Sumatra, to which these Okporo yields of mesocarp oil per acre more nearly approximate. Allowance must be made for the differences in the efficiency of the methods of oil extraction when comparing yields. Rutgers, and it is believed Ives Henry's figures, for lb. of mesocarp

oil per acre are calculated on an extraction efficiency of eighty *per cent.*, while that of the Cooker-press, for similar fruit to that of the Okporo trees, is from sixty to sixty-five *per cent.* [Barnes (13)]. Given an extraction efficiency of eighty *per cent.*, the average yield of mesocarp oil calculated for plot 10 is 904 lb. per acre (average for the years 1922–28). Ives Henry gives a maximum yield of 1,070 lb. per acre for ordinary soils and 1,516 lb. per acre for good soils. It is suggested that the yield per acre of mesocarp oil recorded for plot 10 is a satisfactory figure for a plot of unselected thick-shell type palms; and at the same time, an average annual yield of four cwts. of kernels per acre has been recorded for these palms.

Osok (thin-shell type) Trees.

Conclusions drawn from the yields of the Osok (thin-shell type) trees of plots 6 and 10 are less reliable, owing to the small number of these trees in each plot. From the respective tables A, it is seen that the average weights per bunch are slightly lower, and that the average weights of fruit per bunch and the percentages of fruit weight to bunch weight are considerably lower, than the respective averages for the Okporo trees. The lower percentage of fruit weight to bunch weight is found with all thin-shell type trees and partly neutralises the effect of the high oil content of the fruit of these types, when yields per acre are compared.

From the respective tables B, it is seen that for both plots, the Osok trees give a higher yield per acre of the more valuable mesocarp oil and a lower yield per acre of kernels, compared with the yields obtained from the Okporo trees. Actual results obtained by the Cooker-Press process from the Osok (thin-shell type) fruit of plot 10 give an average increase of fifteen *per cent.* for mesocarp oil, and an average decrease of fifty-six *per cent.* for kernels per acre, compared with the yields recorded for the Okporo (thick-shell type) fruit of this plot.

Plots 11 and 12.

The yields obtained from these two plots may also be conveniently discussed together. They are adjacent to each other and also to plot 10, and are the two smallest plots in size. Both plots contain a considerable number of young trees which have probably affected favourably the yields of a number of the older trees, many of which are growing partly in competition with young palms. Because of this difference in the ages of the palms in plots 11 and 12, the yields are not comparable with those recorded for plots 6 and 10, and, as an indication of the yields to be expected from large plantations of similar palms, the results must be accepted with a certain amount of reservation.

Plot 11 contains Okporo (thick-shell type), Osok (thin-shell type) and both thick and thin-shell Ayara Mbana (mantled type) trees. In plot 12 Okporo and Osok are growing with both thick and thin-shell Afia Oku (green fruited type) palms. The total number of trees of each of these types has already been given, while the numbers of those for which yields can be included (with their calculated acreages) are as follows:—

Plot 11.

20	Ayara Mbana—thick-shell type—trees ...	0·287 acres.
4	„ —thin-shell type—trees ...	0·057 „
21	Okporo trees	0·301 „
7	Osok trees	0·100 „

Plot 12.

6	Afia Oku—thick-shell type—trees	0·086 acres.
7	„ —thin-shell type—trees	0·100 „
10	Okporo trees	0·143 „
4	Osok trees	0·057 „

The percentages of mesocarp oil and kernels to bunch weights (*see* table I for percentages to fruits) used in compiling the respective tables B for plots 11 and 12 are:—

		Mesocarp oil.	Kernels.
Ayara Mbana	—thick-shell type ...	12·4 *per cent.*	4·5 *per cent.*
	—thin-shell type ...	11·0 „	2·3 „
Afia Oku	—thick-shell type ...	11·2 „	4·8 „
	—thin-shell type ...	18·4 „	4·0 „
Okporo type	Average figures used from plots 4, 6 and 10	11·2 „	6·5 „
Osok type		14·5 „	3·4 „

PLOT 11.—TABLES A. AND B.

Planted 25 feet square.

TABLE A.

AYARA MBANA (MANTLED TYPE—THICK-SHELL).

1	2	3	4	5	6	7	8	9	10
Year.	Number of Bunches.	Weight of Bunches in lb.	Average weight per Bunch in lb.	Weight of Fruit in lb.	Average weight of Fruit per Bunch in lb.	Percentage Fruit weight to Bunch weight.	Average number of Bunches per Tree.	Average weight of Bunches per Tree in lb.	Average weight of Fruit per Tree in lb.
Average per annum, 1922–28	188	2,129	11·3	1,298	6·7	52·5	9·4	106·4	64·9

AYARA MBANA (MANTLED TYPE—THIN-SHELL).

Average per annum, 1922–28	39	378	9·7	128	4·3	39·5	9·7	94·5	32

OKPORO (THICK-SHELL).

Average per annum, 1922–28	146	1,638	11·2	1,164	8·3	64	6·9	78	55·5

OSOK (THIN-SHELL).

Average per annum, 1922–28	60	693	11·5	412	7·3	54·5	8·6	99	58·5

TABLE B.

Ayara Mbana (Mantled type—thick-shell).

1	2	3	4	5	6	7	8
Year.	Number of years since Plot planted out.	Number of Trees for which yields are included.	Number of Bunches per Acre.	Weight of Bunches per Acre in lb.	Weight of Fruit per Acre in lb.	Weight of Mesocarp Oil per Acre in lb	Weight of Kernels per Acre in lb.
Average per annum, 1922–28	7–13	20	654	7,408	4,517	919	333

Ayara Mbana (Mantled type—thin-shell).

Average per annum, 1922–28	7–13	4	684	6,631	2,245	729	153

Okporo (thick-shell).

Average per annum, 1922–28	7–13	21	485	5,438	3,865	544	316

Osok (thin-shell).

Average per annum, 1922–28	7–13	7	600	6,930	4,120	991	236

PLOT 12.—TABLES A. AND B.

Planted 25 feet square.

TABLE A.

Afia Oku (Green fruited—thick-shell).

1	2	3	4	5	6	7	8	9	10
Year.	Number of Bunches.	Weight of Bunches in lb.	Average weight per Bunch in lb.	Weight of Fruit in lb.	Average weight of Fruit per Bunch in lb.	Percentage Fruit weight to Bunch weight.	Average number of Bunches per Tree.	Average weight of Bunches per Tree in lb.	Average weight of Fruit per Tree in lb.
Average per annum, 1922–28	40	1,031	26·0	707	19·5	62·5	6·7	171·8	117·8

Afia Oku (Green fruited—thin-shell).

Average per annum, 1922–28	49	884	18·2	615	12·3	57·5	7·0	126·3	87·9

Okporo (thick-shell).

Average per annum, 1922–28	58	1,266	21·9	946	15·8	62·5	5·8	126·6	94·6

Osok (thin-shell).

Average per annum, 1922–28	24	471	20·1	282	11·9	53·5	5·9	118·5	70·5

TABLE B.

Afia Oku (Green fruited—thick-shell).

1	2	3	4	5	6	7	8
Year.	Number of years since Plot planted out.	Number of Trees for which yields are included.	Number of Bunches per Acre.	Weight of Bunches per Acre in lb.	Weight of Fruit per Acre in lb.	Weight of Mesocarp Oil per Acre in lb.	Weight of Kernels per Acre in lb.
Average per annum, 1922–28	7–13	6	465	11,989	8,222	1,343	575

Afia Oku (Green fruited—thin-shell).

Average per annum, 1922–28	7–13	7	490	8,840	6,150	1,627	354

Okporo (thick-shell).

Average per annum, 1922–28	7–13	10	406	8,849	6,614	991	575

Osok (thin-shell).

Average per annum, 1922–28	7–13	4	421	8,314	4,946	1,206	283

From table A for plot 11, it is seen that the average numbers of bunches produced per tree are high, and that the average weights of fruit per bunch and the average percentages of fruit weight to bunch weight are low for both types of Ayara Mbana, as compared with similar averages for Okporo and Osok respectively.

The yields per acre of mesocarp oil (*see* table B for plot 11) obtained from both the thick and thin-shell types of Ayara Mbana, compare favourably with yields recorded for the Okporo and Osok types in this plot. The very low percentage of fruit weight to bunch weight (table A) is responsible for the thin-shell Ayara Mbana giving a lower average yield of mesocarp oil per acre than the thick-shell Ayara Mbana. The low average weight of bunches per tree has produced what is probably an abnormally low yield of mesocarp oil per acre for the Okporo trees of this plot. It is also seen that the yield per acre of kernels in proportion to mesocarp oil, for the thick-shell Ayara Mbana, is lower than the proportions recorded for other thick-shell types.

It is from plot 12 that the highest yields per acre have been obtained and both the Okporo and the Osok trees of this plot have been given the best yields recorded for these types at Calabar.

Table A for plot 12 shows that the average numbers and weight of the bunches harvested from this plot are uniformly good for all the four types. The Afia Oku (green fruited) palms have given excellent yields and the most noticeable feature is the relatively high percentage of fruit weight to bunch weight recorded for the thin-shell Afia Oku type. Average yields per tree obtained from plot 12 are high for all types.

Table B for plot 12 gives calculated yields of mesocarp oil per acre, which more nearly approach Rutger's estimates than any other Calabar yields. The best yields of mesocarp oil and kernels per acre for plots 11 and 12, obtainable by the Cooker-Press, given approximately in cwt. per acre, are :—

Type of Fruit.	Mesocarp oil per acre.	Kernels.
Afia Oku—thin-shell type	$14\frac{1}{2}$ cwt.	3 cwt.
Afia Oku—thick-shell type	12 „	5 „
Osok—plot 12	$10\frac{3}{4}$ „	$2\frac{1}{2}$ „
Okporo—plot 12	$8\frac{3}{4}$ „	5 „
Ayara Mbana—thick-shell type ...	$8\frac{1}{1}$ „	3 „
Osok—plot 11	$8\frac{3}{4}$ „	2 „

The yields obtained from plot 12 suggest that the thin-shell Afia Oku is the most promising of the Calabar types. It is difficult to attempt to estimate how far these yields, which were obtained from a few trees only, can be repeated under plantation conditions. Very satisfactory yields may be obtained from several of the Calabar types if the large number of the low yielding trees, recorded among the Okporo type trees in plot 6 and 10, can be reduced in future plantations by breeding only from high yielding trees. However, while at the present time it is possible to breed from high yielding trees, it is as yet impossible to guarantee the trueness to type of the progeny.

Waters (lit. cit.) considers that properly managed plantations of the Deli type will give an average yield of three-quarters of a ton of mesocarp oil per acre in Sumatra, when in full bearing. There appears to be every indication that a similar yield will be obtainable in the future in Nigeria from such a palm as the thin-shell Afia Oku. Though such a yield on a plantation scale can hardly be expected from the immediate progeny of the best Calabar palms, it is suggested that better results can be immediately anticipated than the average yield of six and half cwt. of mesocarp oil and four cwt. of kernels recorded for plot 10. This anticipated improved yield would be obtained by :—

(*a*) Factory extraction giving a higher efficiency than that of the Cooker-Press process.

(*b*) Breeding only from high yielding trees to improve the average yield per tree.

(*c*) Breeding from thin-shell type trees to obtain a fair proportion of the thin-shell types in the immediate progeny and thus giving some fruit from the plantation with a high percentage of mesocarp.

Mesocarp Oil Extraction at Calabar.

The mesocarp oil has been extracted at Calabar from the different types of palm fruit by two processes. These are the modified native washing process, and the Cooker-Press process, to which reference has already been made. These two processes are now described.

Modified Native Washing Process.

This process was used from 1923 until mid 1926 and the writer is indebted to an unpublished report by Mr. Roebuck for the description. Briefly the method employed was as follows :—

(*i*) The fruits were placed in an iron pot, with a small quantity of water to prevent burning, and cooked until soft enough to be depericarped.

(*ii*) The cooked fruits, after being beaten with pestles, were placed on an iron tray and the oil was washed out first with hot and then with cold water.

(*iii*) The oil was allowed to rise to the surface of the receptacle containing the washings and was then skimmed off. These skimmings were placed in an iron pot and boiled and the oil skimmed off and weighed.

(*iv*) The washings were sometimes allowed to stand overnight and the oil skimmed off again.

Cooker-Press Process.

The Cooker-Press process was employed from mid 1926 to mid 1928 and is described by Barnes (13). Briefly this method is as follows:—

(*i*) The fruits are cooked in the Rapid or Pioneer Cooker and after mashing with pestles are pressed while still warm.

(*ii*) After the first pressing, the nuts are picked out and the mesocarp is heated and then pressed.

(*iii*) After the second pressing, the mesocarp is beaten in a mortar, re-heated and then pressed a third time.

The mean extraction efficiency of the Cooker-Press process is given by Barnes (lit. cit.) as 63·5 *per cent.* for the fruit extracted at Ibadan, which is mostly of the ordinary thick-shell type.

Results obtained from the Two Extraction Processes.

Table I gives the results obtained from the two extraction processes at Calabar. Column 1 gives the type of fruit treated and column 2 the number of the plot. Each type of fruit was extracted separately for all plots, with the exception of the Okporo and Osok fruits from plots 11 and 12 which were treated together, the results for which are excluded from table I. Column 3 gives the number of extractions for which figures are averaged and column 4 the average weight of fruit treated per extraction. It is seen that the results for all types, except Okporo, are calculated from the rather small quantities of fruits that were available at each harvest. Column 5 gives the approximate percentage weights of mesocarp. These were obtained by subtracting the weight of nuts at each extraction from the weight of fruits treated. Column 6 gives the actual

average percentages of mesocarp oil, and column 7 of kernels obtained from the fruit treated. Column 8 gives the average percentages of dry shells to fruit treated. These were obtained by subtracting the weight of kernels produced from the weight of dry nuts before cracking. It is necessary to dry the nuts before cracking so that the kernels can be readily separated from the shells. A loss of moisture occurs during drying, from both the kernel and the shell, and reduces the relative proportions to fruit of both the kernel and shell.

TABLE No. 1.

Results of Two Extraction Processes.

Process I.—During 1st Period—1923 to mid 1926—by modified Native Washing Process.—

1	2	3	4	5	6	7	8
Type of Oil Palm Fruit extracted	Plot.	Total Number of extractions.	Average weight of Fruit in lb. treated per extraction.	Percentage weight of Mesocarp to Fruit by Difference.	Percentage weight of Mesocarp Oil to Fruits.	Percentage weight of Kernels to Fruits.	Percentage weight of Dry Shells to Fruits by diff.
OKPORO. Thick-shell ...	4	40	367	42·0	10·4	10·8	42·2
	6	47	573	44·0	11·2	10·8	41·2
	10	46	859	43·0	11·1	10·7	42·3
OSOK. Thin-shell ...	4	45	76	62·7	14·5	6·5	22·4
	6	26	29	61·9	14·1	6·9	18·0
	10	37	45	63·7	13·8	7·6	17·9
AFIA OKU. Green-fruited. Thick-shell	12	30	68	43·0	11·0	9·7	34·3
AFIA OKU. Green-fruited. Thin-shell	12	30	45	62·0	16·1	7·1	21·0
AYARA MBANA. Mantled. Thick-shell	11	36	98	50·0	11·9	9·1	32·4
AYARA MBANA. Mantled. Thin-shell	11	33	13	50·5	13·5	6·3	18·6

TABLE No. 1—*continued.*

Process II.—During 2nd Period—mid 1926 to mid 1928—by Cooker-Press Process.—

1	2	3	4	5	6	7	8
Type of Oil Palm Fruit extracted.	Plot.	Total Number of extractions.	Average weight of Fruit in lb. treated per extraction.	Percentage weight of Mesocarp to Fruit by Difference.	Percentage weight of Mesocarp Oil to Fruits.	Percentage weight of Kernels to Fruits.	Percentage weight of Dry Shells to Fruits by diff.
OKPORO. Thick-shell ...	4	26	424	38·5	17·0	10·3	43·7
	6	27	679	38·0	17·6	10·0	43
	10	27	925	37·5	17·8	10·8	45·2
OSOK. Thin-shell ...	4	26	106	57·5	27·7	5·6	21·7
	6	22	30	64·5	27·4	7·3	14·3
	10	25	51	62·0	27·8	6·8	15·7
AFIA OKU. GREEN-FRUITED. Thick-shell	12	26	82	44·0	19·3	8·2	30·5
AFIA OKU. GREEN-FRUITED. Thin-shell	12	25	49	65·3	32·0	7·1	13·9
AYARA MBANA. MANTLED. Thick-shell	11	26	98	46·0	24·4	8·8	35·6
AYARA MBANA. MANTLED. Thin-shell	11	25	18	56·8	30·2	6·1	15·7

The figures given in Table I are self-explanatory, and show in lb. the percentages of mesocarp oil and of kernels, to fruits obtained by the two extraction processes from the different types for each plot. From the Okporo and the thick-shell Afia Oku types, an increase of over fifty *per cent.* above the yield of mesocarp oil from the washing process has been obtained by the Cooker-Press process, while from the thick-shell Ayara Mbana and all the thin-shell types, the percentage increase is about one hundred. The percentages of mesocarp to fruit obtained by the Washing process are probably more accurate than those given by the Cooker-Press process. Owing to the circumstances under which the extractions were carried out a margin of error must be allowed, especially where only small average quantities of fruit were treated at each extraction The results, however, give valuable information of the yields that can be obtained from the different types of fruit by these two extraction processes.

Frequency Distributions of Individual Tree Yields.

In Tables 2 and 3, the frequency distributions of the yields; in lb. of bunches per annum, are given for Okporo (thick-shell type) trees for plots 6 and 10. These tables show how the average yields per acre for both these plots have been reduced by the large number of trees whose annual yields fall into the lowest classes and weight the distributions. The high proportion of the low yielding trees is most marked in plot 10 which is the more closely spaced. (twenty-five feet square as opposed to thirty feet square for plot 6)

Variation in yield is to be expected from a large population of palms, and low yielding individual trees will always occur. It is obvious that a high average yield of bunches per tree is of equal importance as a high oil content in the fruit. Plantations established with palms of unknown parentage are likely to contain large numbers of low yielding trees, as well as a high proportion of trees with fruit of poor quality.

Further Data from the Calabar Palms.

It is hoped to include further information and data from the Calabar plantation palms in a future paper.

TABLE No. 2.

Plot 6—Okporo (thick-shell) Trees.

Frequency distributions of yields in lb. of bunches per annum for individual trees over the period 1922–28. Yields of 125 trees included for each year.—

Bunch Yields in lb. per annum—Class nterval, 15 lb.	Number of trees in each year whose yields in lb. of bunches fall within limits of each class.							Total Frequency Distribution.
	1922.	1923.	1924.	1925.	1926.	1927.	1928.	1922–28.
361—	...	...	1	...	1	...	...	2
346—	...	...	...	...	...	1	1	2
331—	...	...	...	2	...	...	1	3
316—	...	...	...	1	1	...	...	2
301—	...	...	...	1	1	1	1	4
286—	...	...	1	2	1	...	...	4
271—	...	...	2	...	3	...	...	5
256—	...	...	...	1	1	1	4	7
241—	...	1	...	2	...	1	3	7
226—	1	...	4	2	2	1	4	14
211—	2	3	3	6	...	...	1	15
196—	4	1	2	6	3	...	3	19
181—	9	1	4	11	7	4	8	44
166—	2	2	7	7	5	7	7	37
151—	8	4	8	8	9	6	9	52
136—	8	11	10	6	12	4	12	63
121—	6	10	12	11	7	11	13	70
106—	9	15	8	4	9	6	5	56
91—	12	11	8	11	5	17	9	73
76—	10	15	19	9	8	11	8	80
61—	10	18	15	10	8	12	9	82
46—	16	15	9	7	15	7	9	78
31—	13	9	4	8	8	14	11	67
16—	5	6	2	4	10	9	5	41
0—	10	3	6	6	9	12	2	48

TABLE No. 3.

Plot 10—Okporo (thick-shell) Trees.

Frequency distribution of yields in lb. of bunches per annum for individual trees over the period 1922–28. Yields of 220 trees included for each year.—

Bunch yields in lb. per annum—Class interval, 15 lb.	Number of trees in each year whose yields in lb. of bunches fall within limits of each class.							Total Frequency Distribution.
	1922.	1923.	1924.	1925.	1926.	1927.	1928.	1922–28.
391—	1	...	...	...	...	...	1	2
376—	...	...	...	...	...	...	...	...
361—	...	...	...	...	...	...	...	...
346—	...	...	1	2	...	...	...	3
331—	1	...	...	...	...	...	1	2
316—	...	1	1	...	...	...	...	2
301—	...	...	...	1	1	2	...	4
286—	1	...	...	2	1	1	1	6
271—	...	2	1	2	2	...	...	7
256—	2	1	1	3	...	1	4	12
241—	3	1	1	4	...	1	2	12
226—	5	2	4	1	3	2	1	18
211—	1	3	7	4	2	2	5	24
196—	4	3	11	4	2	1	2	27
181—	7	3	11	11	9	5	5	51
166—	7	5	4	7	4	6	8	41
151—	7	12	15	12	7	5	13	71
136—	13	14	14	10	10	10	12	83
121—	10	17	17	15	13	13	19	104
106—	23	24	20	15	9	13	18	122
91—	14	14	13	10	15	11	15	92
76—	20	15	27	21	18	25	21	147
61—	11	14	17	15	17	21	19	114
46—	19	26	18	21	32	19	19	154
31—	20	16	14	23	25	32	19	149
16—	19	15	8	20	22	16	16	116
0—	32	32	15	17	28	34	19	177

PART III.

Selection Work on the Oil Palm.

The main object of the oil palm work recently undertaken at Calabar was to self-fertilise the best trees, so that the possibility of producing superior lines for planting might be investigated. Work of this nature, owing to the number of years that must elapse between each successive generation, will take a long time to complete. However, during this time, not only will valuable information be collected, but seed of known parentage for planting can be produced long before plants breeding true to type are obtained. The actual selfing at Calabar was in the charge of a native assistant, who fortunately had had previous experience of work of this nature at Ibadan. During the first months he worked under close supervision but later, owing to the writer having charge of other selection work at Ibadan, supervision had to be confined to flying visits.

Flowering of the Oil Palm.

The flowering of the oil palm presents a difficulty in work of this nature. On some trees the male and female inflorescences follow each other in short cycles; or even, at times, alternate male and female inflorescences are produced. On others, the cycles are more prolonged and occur at greater intervals. A resting period of varying duration, in the production of flowers, is noted in many instances but does not appear to occur at the same time on all trees. This resting period occasionally lasts almost for a whole year, for it is observed that several of the palms that have given high average yields over the period for which we have data, have produced only one or two bunches during a single year. Bisexual inflorescences, while not common yet by no means rare, appear to occur fairly frequently on a few trees. Natural self-fertilisation by this means does not seem possible as the male flowers shed their pollen several days before the stigmas of the female flowers are receptive.

Flowering in the oil palm requires further investigation; Mason and Lewin (15) found that flowering at Ibadan was affected by rainfall distribution and suggest further that the relative length of night and day is of importance. They also point out that the sex ratios of individual trees vary greatly.

Selecting Parent Trees.

As nothing was known as to how the various types growing at Calabar would behave when self-fertilised, it was decided to include at least one example of each type in the first selections. Female inflorescences of these trees (Table V) have been self-fertilised and

the nuts produced are now being grown at Ibadan. The first selection was based mainly on the gross yield of bunches produced over the period 1922-27, after allowing for the probable age of the trees and excluding outside trees where possible. Selection was also based on the result of a rough field analysis of the fruit (described later *see* Table IV). The percentages of fruit weight to bunch weight appear to be fairly constant for each type. The small differences observed between trees of the same type are unreliable owing to the irregular dates of harvesting.

A large number of the thick-shell type trees were included, as it was a comparatively easy matter to obtain high yielding trees here, owing partly to their average yield being higher than that of the thin-shell type, and partly to their being a much larger population from which to select.

Method of Pollination.

As a first step in the propagation of superior types of oil palms, Hill and Mason (16) worked out a method of artificial pollination. This method has been followed with certain modification that are described.

The method is as follows:—

In order to control pollination, bags of green willesden canvas, that had been treated with mineral oil, were used to enclose the inflorescences. For inspection, and the introduction of pollen, these bags were each provided with a small window. The bags, approximately twice as large as the inflorescences, were fitted about four days before the stigmas became receptive, after the spathe and encumbering leaves had been cut away. Supports were placed inside the bag to prevent it touching the flowers and, the spadix having been washed with a solution of formalin, the bag was securely tied over a grease band on the peduncle. When the stigmas were judged to be receptive, the window was removed, the pollen introduced through a glazed paper pipe, and the window replaced. The bag was taken off when all the stigmas had withered, and all immature flowers were removed. Pollen was stored in calcium chloride desiccators. Further inflorescences were bagged as controls and were left unpollinated, the windows being opened when the stigmas were receptive and then replaced as in the pollination process.

Modified Method.

Once the parent trees have been selected, it is necessary to accumulate a stock of pollen for each tree before selfing can commence. The assistant visits each tree in turn and records in a note book the degree of development and sex of all the young

inflorescences found. A chart is kept showing the stages of development of all inflorescences for each tree, and affords information as to which trees should be visited on any given day. Once a supply of pollen is available, female inflorescences are bagged as they appear, and are self-fertilised when the majority of the stigmas are receptive. No female inflorescences are bagged unless pollen is available, and where a succession of developing male inflorescences is observed the earlier ones can be ignored. On the day of pollination an indelible label is attached giving a number to the inflorescence, and particulars are recorded against the number in a book. While the bunches are developing, the trees, must be visited from time to time for inspection, and to see that the labels are intact. When mature the bunch is harvested, the fruits cut out, and the mesocarp removed before the nuts are sown.

The Collection of Pollen.

It is considered advisable to bag the male inflorescences before anthesis, to prevent possible contamination of the pollen. This is done on what is judged to be the second day previous to anthesis; the spathe and any necessary leaves are removed, as has been described, and the inflorescence is sprayed with a five *per cent.* solution of commercial formalin. This will kill any viable pollen, and assists in the removal of weevils and other insects, that are always present.

Normally, anthesis of the male inflorescence takes place during a period of a few hours. When enclosed in a bag, anthesis of all the flowers does not usually take place on the same day and pollen cannot be collected from the whole inflorescence.

When the majority of the flowers are mature, the inflorescence is cut off, and the pollen shaken on to clean papers and dried in the sun for a short time. It is possible to increase the yield of pollen by leaving the entire inflorescence in the sun for a short while prior to this. The pollen is then sifted from the empty anthers, which are mixed with it, and placed in envelopes which are then sealed. Sufficient pollen for a single female inflorescence is placed in each envelope, and from two to four envelopes should be obtained from a large male inflorescence. The envelopes are kept in calcium chloride desiccators until required.

The formalin spray is constantly in use during all operations involving the handling of pollen, to prevent contamination which otherwise would be likely to occur.

Viability of the Pollen.

The pollen germinates well up to a month from collection, after which viability decreases. Pollen three and four months old was successfully used; but it was the practice to replace pollen in the

desiccators as fresh inflorescences were obtained, and no attempt was made to determine how long it could be kept. In pollinating, the freshest pollen available was always used.

Preparation and Pollination of the Female Inflorescences.

The development of the female inflorescences is noted, as has been described, and when judged ready for bagging, the spathe and leaves are removed and the spines of the main branches and bracteoles are cut off to facilitate handling and bagging. The opening of the flowers is irregular, but they usually open over a period of three days as described by Heusser (8). The one or two flowers, that have been observed in a few instances to open abnormally early, present a difficulty, for they are by no means easy to discover without doing damage to the inflorescence. For example, an immature inflorescence was observed with a single withered flower; bagged on the same day, the rest of the flowers did not open until elven days later. Bagging appears to retard the opening of the flowers slightly. This is particularly so with the mantled form, which is the most difficult to bag successfully for this reason. In carrying out the selfing, the aim is to bag the inflorescences rather earlier than is described by Hill and Mason (lit. cit.), so that the inflorescences are in the bag about a week before the opening of the flowers. The previously described procedure of bagging is observed, and the inflorescences are then watched for the opening of the flowers. Once the majority of the flowers are seen to be open, the bag is lifted and pollen from an envelope dusted over the inflorescence, the operation being completed and the bag replaced as rapidly as possible. The bag is left in place until all the stigmas have withered, a period of one to three weeks. It is considered unsafe, to attempt to remove immature flowers, as if this is done, there is a risk of the worker failing to discover them all. Further, it was not found practicable to pollinate through the window as described by Mason and Hill (lit. cit.); for, besides the difficulty of covering the inflorescence with pollen, the windows are difficult to replace satisfactorily while the bag is in use. Again, for the reason given above, it is unsafe to attempt to use an inflorescence once a few flowers have commenced to open.

Reliability of the Method.

As a control on the work, one or two inflorescences each week were bagged and left unpollinated. The results from these tests, available at the time of writing, are given below:—

No fruits set	...	...	41
A single fruit set	...	...	2
A few fruits set	...	...	2
Total number bagged		...	45

It is suggested that the probable reason for the four failures reported above was carelessness. As has already been stated, much of the work had to be left to an assistant. The preparation of a single female inflorescence for bagging is a lengthy and laborious operation. Trees actually selected as parents are kept under close observation, and it is a comparatively easy matter to bag their inflorescences at the right time, which, of course, must be done. Controls, however, are bagged on other trees and the finding of an inflorescence in the right condition is sometimes difficult. It is suggested that the two bunches which set a few fruits each were probably bagged too late; and that the assistant, rather than go to the trouble of finding another, in each instance "chanced" them with the result that a few flowers, which had already been pollinated, set fruit. The two inflorescences that set a single fruit each, may be explained in the same way, or may be examples of a single flower opening early and passing undetected; this has already been mentioned.

It is realised that, similarly, a few bunches on the selected trees may have been "chanced." This however is less probable for the reason stated already, and also, because the assistant would regard these as meriting more care than those which were to be left unpollinated and which he might regard as being of little value. A difficulty such as this is insuperable and, while it can be minimised, can never be eliminated. However, the results are regarded as being as satisfactory as can be expected without constant European supervision; and even then, with a large number of inflorescences, accidents might well happen. As a safeguard against mistakes, the progeny of each selfed inflorescence will be kept separate, so that any such mistake may be detected later.

Rough Method of Field Analysis.

Owing to the distance of Calabar from the Laboratory, it was necessary to devise a rough method of field analysis to distinguish, for each type of fruit, which of the trees selected on yield alone would be acceptable on relative percentages of mesocarp, shell and kernel. No great virtue or accuracy is claimed for the method itself, or for the sampling employed, except that, for trees of a similar type, it was adopted as an aid to the selector in judging the relative proportions of the components of the fruit.

The method is as follows:—

1. Once the fruit has been separated from the bunch, it is placed in a box and, at the same time that it is being mixed by hand, about five lb. of fruit are taken out. All infertile fruits are disregarded. From the first sample, four lb. of fruit are then weighed out carefully on druggists' scales. All weighings during analysis are made to the nearest one-fourth oz.

TABLE NO. IV.

Percentages of Mesocarp, Coarse Fibre, Shell and Kernels obtained, by the rough method of Field Analysis described, for certain individual Trees.

Type.	Tree Number.	No. of 4 lb. Samples taken.	Percentage Mesocarp.	Percentage Coarse Fibre.	Percentage Shell.	Percentage Kernel.	Percentage Loss.	Remarks.
Okporo. Ordinary thick-shell type.	68	4	31·4	3·1	46·9	14·8	3·6	Discarded.
	97	3	40·3	4·1	36·9	15·5	3·2	"
	141	3	45·2	3·5	30·7	16·9	3·6	
	120	3	36·3	4·3	41·2	15·0	3·1	"
	222	3	47·5	5·7	32·6	10·7	3·5	
	224	3	46·8	2·3	35·7	11·7	3·5	"
	233	5	47·1	4·8	33·6	11·6	2·9	
	234	2*	40·9	4·4	36·6	14·5	3·5	"
	256	2	52·2	4·3	31·2	10·3	1·9	
	703	3	45·8	3·4	33·0	14·1	3·6	
	765	2	32·6	3·1	49·6	10·0	4·7	"
Osok. Ordinary thin-shell type.	224	3	62·1	6·0	20·6	8·2	3·2	
	339	2	62·5	7·6	16·0	9·2	4·7	
	340	2	61·1	4·3	21·9	9·7	3·0	
	387	5*	66·6	3·3	13·8	13·2	3·0	
	416	3	76·4	6·1	7·8	8·8	0·9	
Afia-Oku. Green-fruited thick-shell type.	341	2	53·3	3·9	28·8	10·8	3·1	
	371	4	36·3	2·9	46·0	11·2	3·5	Discarded
	375	2	50·2	3·1	31·2	12·1	3·2	
Afia-Oku. Green-fruited thin-shell type.	366	2	68·8	4·7	16·4	7·6	5·5	
	373	4*	57·9	3·3	22·4	12·2	4·2	
	384	2	58·3	2·9	24·6	11·1	3·0	
Ayara Mbana. Mantled thick-shell type.	261	3	57·0	7·6	22·5	10·2	2·5	
	262	4	54·3	6·3	27·1	8·7	3·5	
	268	3*	53·1	7·0	27·4	9·0	3·5	Discarded.

Note :—An asterick in the third column denotes that one of the samples was less than 4 lb. in weight.

TABLE No. V.

Yields and Particulars of the Selected Trees.

Type.	Number of tree.	Height in feet.	Yield in Bunches–Period 1922–28 inclusive.				Average weight produced in lb. of fruit per annum.	Percentage fruit weight to bunch weight.
			Total number of bunches.	Total weight in lb.	Average weight per bunch in lb.	Average weight produced in lb. of bunches per annum.		
Okporo. Ordinary thick-shell	141	10·0	44	778	17·7	111	97	65
	222	16·0	47	1,417	33·7	202	134	67·5
	224	17·5	58	1,300	22·4	186	139	66·5
	233	16·0	56	1,675	29·9	239	136	61·5
	256	14·5	99	1,533	15·5	219	159	63·5
	703	14·0	61	1,983	32·5	283	218	69·5
	706	13·0	47	1,277	27·2	182	105	63·5
Osok. Ordinary thin-shell	200	14·0	35	1,139	32·6	163	72	52
	244	12·0	73	1,245	17·1	178	99	53·5
	339	10·0	55	1,262	22·8	180	97	49
	340	13·0	33	1,046	31·7	149	80	57
	387	2·0	45	527	11·7	176	103	54·5
	416	19·5	30	557	18·6	80	52	55·5
	770	9·5	44	633	14·4	90	55	60
Afia-Oku. Green-fruited thick-shell.	341	10·0	47	1,275	27·1	182	128	69·5
	375	15·0	52	2,105	40·5	301	157	59·5
Afia-Oku. Green-fruited thin-shell.	366	14·0	51	962	18·9	137	85	60
	373	10·0	48	1,269	26·4	181	108	58·5
	384	7·0	63	1,042	16·5	149	103	59·5
Ayara Mbana Mantled type thick-shell.	261	13·5	105	1,197	11·4	171	126	61·5
	262	17·0	69	1,117	16·2	160	85	48·5
Ayara Mbana Mantled type thin-shell.	292	12·5	104	1,125	10·8	161	77	39·5

Note I.—Tree 387 is a young tree which commenced to bear in 1926.

II. The figures given in the last two columns for average fruit weight and percentage fruit weight to bunch weight are calculated on :—

2 years results—1926–27 for tree 387.

3 „ „ —1924 and 1926–27 for trees 141, 200, 222, 2[illegible] and 233.

4 „ „ —1924–27 for the rest of the trees.

III. The yields of fruit in 1928 have been excluded on account of the interference caused by selfing.

2. The four lb. sample is then cooked and washed to separate the mesocarp from the nuts. The nuts, which are wet from the washing, are then placed for a short time in the sun and are weighed when dry. The mesocarp is cooked and washed to separate out the coarse fibre, which is also dried and weighed. The weight of mesocarp (plus exocarp) is obtained by difference, the weights of nuts and coarse fibre being added together are subtracted from the four lb. sample and the difference entered as weight of mesocarp.

3. As it is impossible to separate kernels from shell, if the nuts are cracked at once, the nuts are now dried for about two days and then weighed again. The difference between the two nut weighings can only be recorded as a percentage loss and slightly reduces the percentages for kernels and shell. Immediately after the second weighing the nuts are cracked and the kernels weighed. The shell weight is obtained by difference.

Results of Field Analysis.

Table IV gives the results for some of these analyses. Only trees are included for which the results of the analysis of at least two samples are available. As will be seen from the last column, certain trees have been discarded with high shell and low mesocarp percentages.

Selected Trees.

It is seen that selection has been based on yield and rough field analysis. Table V gives the yields of the selected trees. The total number of bunches, the total weight of bunches, with the average weights per bunch and of bunches per annum, for the period 1922 to 1928, are included. The height of each tree early in 1928 is recorded. The average weight of fruit produced per annum, with the percentage of fruit weight to bunch weight are also given for those years for which figures are available. Fruit weights on the selected trees for 1928 are excluded, as the interference caused by selfing makes these weights unreliable.

ACKNOWLEDGMENTS.

In conclusion, the writer wishes to record his indebtedness to Mr. C. B. Taylor for valuable help and criticism during the preparation of this paper; also to the Superintendents of Agriculture, Umuahia, especially to Capt. S. M. Gilbert, who have given every assistance and from whose observations, individual tree yields and extraction data have been obtained.

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EXPERIMENTS ON THE LIFE HISTORY AND CONTROL OF THE YAM BEETLE IN THE BENUE PROVINCE OF NIGERIA.

BY

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In the Seventh Annual Bulletin of the Agricultural Department an account was given (2) of the first season's work on the Dynastid beetle, *Heteroligus claudius*, Klüg., which had become a serious pest of yams in Nigeria, especially in the Benue Province. In that paper an account was given of the extent of the infestation in the Benue Province in 1927 with details of the life cycle as worked out in cages. In the same Bulletin Golding (1) gave an account of the infestation in the Benin and Warri Provinces.

In May, 1928, the writer again proceeded to the Experimental Farm, between Abinsi and Katsina Ala, to continue the investigations and remained there until early in March, 1929, when he returned to Ibadan *via* parts of the Onitsha and Benin Provinces where the beetle attack had been serious and where larvæ were discovered. In April and May another tour was taken in the Onitsha district.

The present paper is an account of the beetle attack in the Benue Province in 1928, of further work on the life cycle and of a large scale trial of control methods.

THE 1928 INFESTATION.

The number of beetles found on the farms was very much smaller than in the previous season over the greater part of Munshi country, and serious damage was restricted to one belt extending from Tombo West, near Gindi, through Wunnune and Ikpa towards the railway. The centre of the infestation has therefore moved north-west since last year when Tombo West was the centre of the trouble and it seems that in 1926 the heaviest damage was again further east in Ugondo.

Whereas last year beetles were commonly taken coming into the lighted houses in the evening, this year only two were seen thus, on May 16th and 17th. Two more were taken in a light trap on the Plantation on June 18th.

The average total length of the developmental stages as worked out in the previous season was as follows:—

Table No. 1.

Egg period ...	...	16 days.
Larval period	...	122 ,,
Pupal period ...	...	16 ,,
Total ...	...	154 days or 22 weeks.

In the cages in 1927 most eggs were laid during the week ending November 26th. It was therefore to be expected that most beetles would emerge at the end of April though actually they did not begin to appear in the farms until late May and were most numerous considerably later. It therefore seems that conditions in the field are either not comparable to those in the cages or that the beetles had emerged some time before they infested the Munshi yams.

The first beetles were found on a native farm on June 8th though they had been reported by May 21st. On this particular farm, Akpa in Yandev, ten hurricane lamps, standing in bowls of water, were placed in a ring round one plot of yams, (0.6 acre) and were lit alternate nights from May 21st. It was hoped to gain some indication of the direction from which most beetles arrived, but none were collected although there were a number found in the farm.

In cage experiments, Golding (1) observed that the beetles tended to bury deeper in the soil as the season advanced. The same was found in the farms. Up to the end of July excavation of the soil to a depth of about one foot unearthed the beetles in the yam heaps. Thus at Wunnune on July 17th, 412 beetles were found per 1,000 heaps and on July 31st none were found by similar methods. On October 18th and 20th some heaps were examined to a greater depth, about two feet, and 2,875 beetles were found per 1,000 heaps.

It seems that the number of beetles in the farms increases through the season up to about September. In the examinations of October 18th and 20th, of the beetles found only nineteen *per cent.* were females and it seemed likely that they were migrating to oviposit elsewhere. However, twenty-one beetles were collected on October 22nd and 25th on the Plantation and only twenty-nine *per cent.* were males.

The following table shows the proportion of the sexes in all beetles collected from May to October and it will be seen that there

was no definite variation and that the sexes were fairly evenly divided throughout. No beetles were found after October 25th.

TABLE No. 2.

Month.	Total number of beetles collected.	Males per 100 females.
May	2	100
June	134	91
July	490	100
August	91	85
September ...	61	69
October ...	43	166

LIFE HISTORY.

DIFFERENT TYPES OF YAM BEETLE.

The only two species of Dynastid beetle that have been reported feeding on yam tubers are *H.claudius* and *Prionoryctes caniculus*, Arrow, (3). In the previous paper (2) it was mentioned that a "curious feature of the attack was that towards the end of the season when the yams were being harvested many of the beetles were of a small type". It is now clear that this type is a distinct species of the same genus, as yet unidentified.

For measuring the variations in size of beetles the length of the mid dorsal margin of the elytron from the tip of the scutellum to the tip of the elytron was taken, and from June 26th all beetles were measured. For the typical male *claudius* the measurement varied from 14.8 mm. to 19.9 mm. with a mean of 16.9 mm. : for the female, from 13.6 mm. to 21.2 mm. with a mean of 17.6 mm. With the "small type" the sexes are not readily distinguished and for all of these beetles the measurement varied from 12.3 mm. to 14.6 mm. with a mean of 13.5 mm.

The sexes of *claudius* are readily distinguished by the terminal abdominal segiments but the male and female "small type" are very similar.

In 1927 the oviposition period of *claudius* extended from October 19th to December 23rd, and in 1928 from October 17th to January 8th. In 1928 the "small type" laid from May 12th to June 27th, and in 1929 from February 19th to March 3rd. Several *claudius* have been bred through from adult to adult, but all the larvae of the "small type" died although they fed freely on yams.

Except for one taken on July 2nd, all the "small type" were found after the middle of August and chiefly in October.

The average size of the adult *claudius* varied very little but those taken in September and October were slightly larger.

The colour of the adult *claudius* varies from light brown to black. When the beetles emerge they are light brown and they darken over a period of weeks and sometimes months. Records were not kept of the colour of June caught beetles, but from July to October the percentage numbers of brown, or what are presumed to be recently emerged beetles, were as follows:—

Table No. 3.

Month.	No. beetles examined.	% brown.
July	293	38
August	114	58
September ...	60	60
October ...	43	51

The following life history notes refer only to the typical *H.claudius*.

OVIPOSITION.

In 1928 most of the beetles collected in farms in May and June lived until the oviposition season—October. But in 1929 none of the beetles collected in June laid any eggs and most died the same month. Of sixty-four females caged in July only fourteen laid eggs.

Ten beetles, of which six were females, were bred from larvæ, one of these died in June but the rest died in late November and early December.

The following table shows the time of death of all male and female beetles (excluding those unfed) collected through the season.

Table No. 4.

	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Male ...	5	27	9	4	12	24	16	—
Female ...	3	33	3	4	7	15	22	4

These figures taken with those of Table No. 3 rather indicate that a number of beetles live through the dry season and die about July. Of the beetles collected in 1927 the last died on May 18th, 1928.

The first egg was laid on October 17th, 1928, and the last on January 8th, 1929, so that the oviposition period was practically the same as in 1927—October 19th to December 23rd. The greatest number of eggs were laid during the week ending November 24th as in the corresponding week in 1927.

LARVAL FOODS.

The larvae have been given a variety of roots for food, with the following results :—

Yam	eaten well.
English potato	,, ,,
" Kuru-agbishi " (1)	,, ,,
Cassava	eaten slightly.
Sweet potato	,, ,,
Groundnuts	eaten very slightly.
" Anhil " (2)	,, ,, ,,
Hæmanthus rupestris	not eaten.
Gladiolus 2 spp.	,, ,,
Gloriosa superba	,, ,,
Plectranthus floribundus: " Agbishi " ...	,, ,,
" Achaku " (3)	,, ,,
" Nimbe " (4)	,, ,,

Larvae kept in soil with humus but without any roots all died. Potato is not grown in Munshi country and only very small quantities of " kuru-agbishi " are grown.

LARVAL HABITAT.

Extensive search in Munshi country has failed to show the normal larval habitat, though larvae have been found in numbers by the Niger to the north of Onitsha.

Last year's yam farms, especially those known to have been heavily infested by beetles and which were low lying, were examined in various parts of the Province. The old yam heaps were removed and the soil excavated down to hard sub-soil which obviously could not support larval life.

It will be seen from the table of rainfall (Table No. 5) that the dry season was severe and few farms examined seemed moist enough for the larvæ of *claudius*, though other melolonthid larvæ were found. Especial attention was given to the farm at Wunnune where many beetles were found in October, with a high percentage of males. This farm lies in a shallow valley about fifty yards from a small stream with the intervening ground rather marshy in October. On October 23rd and 24th, a trench was cut from the edge of the farm to the stream, 150 feet long, 4 feet wide and 2 feet deep. From January 24th to 26th, ninety-seven heaps in the farms were searched. Rubbish heaps in the adjacent village were examined and one *claudius* elytron was found. From February 2nd to 4th further

1. An edible tuber probably closely allied to *Plectranthus floribundus*.
2. A rhizome used for gum making. Flowers are orchid like and are used for soup.
3. A very large tuber only eaten in its early stages by the Munshi (*Leguminosae*).
4. A type of yam.

search was made in the same locality, in the farm itself, the surrounding bush and in an old cassava farm. A very wet farm at Bassi (Tombo West) was badly infested when examined in July. The farm was examined for grubs on February 5th, but the ground then seemed much too dry for the grubs. The surrounding bush, except beside a small stream was also very dry and nothing was found. Many other farms gave the same negative results. It seems fairly definite that during a severe dry season, *claudius* cannot breed in the average Munshi yam farm.

Reports had been received that the beetle was well known in the Anam district of the Onitsha Province and in the Kukuruku Division of the Benin Province. Agoleri, Onitsha, was visited in March and April. The natives there knew of a grub (ikpokilikpo) to be found in the yam farms which they said developed into the yam beetle (ebe). Most of the yams of the western side of the Onitsha Province are grown besides the banks of the Niger and its tributaries or on small islands, and the Anam peninsula is one of the main yam growing areas. This is all very low lying country and many of the yam farms are submerged during the high water of September or October. Owing to the rich soil yams are cultivated on the same ground for several years consecutively. Most are sown early as they have to be harvested in August, but some farmers were sowing in March and they made the new heaps when actually sowing. Several farms just across the river Anambra from Agoleri were examined and many *claudius* larvæ were found about two inches below the surface. The grassland surrounding the farms was then examined and a number of *claudius* larvæ of various sizes up to three quarters full grown were quickly unearthed amongst the grass roots. One dead male beetle was found under one tuft of grass and two elytra under another. The natives are of the opinion that though few larvæ are in the actual yam farms in March they move there after the early rains to feed on the seed tubers, and that in the past up to five larvæ per plant have been found. Grubs seem only to be present in the low land. The beetles themselves seem to be more numerous on the high land, but this is probably only due to the fact that the farmers do not examine their yam heaps for beetles until the yams are harvested and by that time many beetles have been driven from the low land by the very moist conditions. The larvæ are found most abundantly on land that has been under yams for several years.

From Aguleri the writer visited Omerum, about thirty miles up the Omerum river and also Igbaku and Aguleri Otu about the same distance up the Anambra River. In none of these places was there any evidence of the larvæ, though the beetles were known as

a minor pest. Farms were then examined on the promontory opposite Onitsha and at Asaba. In the former locality grubs were very common and were killing maize seedlings planted between the yams by destroying their roots. None were found at Asaba. The writer then proceeded up the Niger to Illah and Illushi (Ojigolo). At Illah the grub was more numerous than in any other locality, in the farms near the river and in the bush all along the bank. On one groundnut farm the grubs had killed off about seventy *per cent*, of the seedlings and in the bush they were killing off the grass plants and could be found by pulling up dying plants. No pupæ were found. These farms were examined on May 1st and all the larvæ seemed to be nearly full grown. No grubs were found at Illushi though there was evidence that they were present in some yam farms. Definite evidence was obtained that the grubs are known at Atani south of Onitsha and in the Alabeta creek and Idah north of Illushi. At the time of writing two *H.claudius* beetles have been bred out from larvæ obtained from this Niger breeding ground.

It is evident that the banks of Niger and some of its tributaries and islands, which are flooded in high water form an extensive breeding ground of the yam beetle. The breeding ground extends from Atani in the south to Idah in the north at least. As the grubs are not confined to the yam fields it is obvious that no control of the grub stage is possible in these parts by agricultural methods.

A curious feature of the infestation in this region is that, in spite of the abundancy of larvæ, the farmers do not complain of serious damage by the adult.

Kukuruku was visited from March 18th to 20th. Fugar midway between Auchi and Agenebode was reported to be the centre of the infestation which was very severe. Golding (1) reported considerable damage in the Auchi Division in 1927 and it seems that the beetles first became numerous at Fugar in 1926 and during the last three seasons have greatly reduced the yam crop. It is also reported that in 1924-26 the beetles were severe at Ova, also in Kukuruku, but that since Fugar has been infested the yams there have been free. Before the years of the recent epidemics the beetle was not unknown in Kukuruku but there is no evidence of past outbreaks. During the early rains, probably in May, there are reports of a very definite flight of beetles to the yam farms from, presumably, the Niger breeding grounds. No definite evidence was obtained on the white grubs reported by Golding to feed on the yams in the Auchi district, but it seemed that the only white grubs known to attack yams were found about September.

Around Fugar, old yam farms, new yam farms and various types of bushland beside old farms and near streams were examined without result.

ESTIMATION OF THE INTENSITY OF BEETLE ATTACK.

For comparative purposes it was necessary to devise some method of measuring the intensity of beetle attack,

(*a*) By the number of beetles in the farm, and

(*b*) By the amount of damage.

(*a*) Only after recent rain is it possible to distinguish yam heaps that have been recently entered by beetles and no estimate can be made without disturbing the yam. To determine the " beetle index " of a farm, about 100 heaps are examined in one of the centre rows and the index is given by calculating the number of beetles present in 1,000 heaps. It is only feasible to take this index in June and July before the beetles descend into the deeper soil as the soil can only safely be examined down to the base of the young growing tuber if the plant is not to be damaged extensively. At best this index can only give approximate figures as the depth of the beetles in the soil varies with climatic conditions.

To determine how greatly this examination of heaps impairs the formation of the tubers, heaps were examined in alternate rows in one quarter acre plot on the Plantation with the following results :

Average yield of examined rows, 41 lb.

Average difference of non-examined rows, +8 lb. $\pm$4.2.

Odds that difference is significant, 34 :1.

The experiment was carried out under somewhat arid conditions when the damage was probably greater than when the soil was damp, but it shows that this index should be used sparingly on native farms.

(*b*) The Munshi commences to harvest the ordinary types of yams about August according to his daily needs so that at the end of the rains when the final harvest is made there may be not many tubers left in the farm, although he leaves the plants to form small tubers which are used for seed. The water yams are however not touched until the full harvest in December and January and these tubers are stored in small grass huts until they have dried off sufficiently to be eaten. It is therefore easy to determine the percentage number of water yams damaged by beetles, and throughout the work this method has been used for the accurate comparison of attacks on different farms, and the figure obtained is termed the " damage index ". Small seed yams are not included.

The Munshi grows probably about thirty different varieties of yams, but it has been impossible to compare them all, and only water yams as a whole have been compared with all the varieties of hard yams. Both the " beetle index " and the estimation of percentage damage showed the water yam to be least attacked. On twenty-five farms in Tombo West both types of yam were examined and the average percentage of water yams damaged was thirteen as compared with eighteen for the hard types.

CONTROL METHODS.

Scattering of Heaps.

Owing to the seriousness of the beetle infestation in the Benue Province it was decided that a trial should be made of scattering the old yam heaps before planting the gero as outlined in the previous paper (2).

Objects of the trial.—Although no definite evidence was obtained in 1927 of the breeding habitat of *claudius* there were strong indications that the larvæ developed in the old yam farms during the dry season. It was considered that by scattering the yam heaps after the tubers had been harvested and before the gero was sown, the larvæ or pupæ would be killed by exposure to the heat of the sun. This method of scattering was already practised in most of the southern Munshi Districts where no beetle damage was known. It was decided that a thorough test would be desirable and a large area in the Tombo West District of the Abinsi Division was selected. The farmers were warned through the District Head that it was no more than a trial and an attempt to improve the serious conditions that prevailed. To encourage a good growth of tubers the farmers were also instructed to plant all yams by March 1st, but as by this date many farmers had not planted all their seed the period was extended to March 28th.

Methods.—While the writer was on leave the Superintendents of Agriculture stationed at Yandev undertook the enforcing of the scattering methods on all farmers in the area chosen and at the same time every farm was measured so that it was possible to tell if yams were planted after the close of the planting period. Through the wet season the area was frequently toured to observe the progress of the beetle attack by taking " beetle index " readings. In January and December the damage to the crop within the area was compared by means of the " damage index " with the damage in the surrounding belt of country.

It was impossible to obtain data from every farm as some of the tubers had already been sold or eaten. Other farms had grown an insufficient quantity of water yams. In every determination care was taken that the sample examined was typical. Normally 200-500 yams were examined per farm with samples taken from two or more womens' plots when possible.

Description of Area.—The 1928 Tombo trial area consisted of forty-one square miles towards the south of the Tombo West District. To the east the area was bounded by the River Katsina which is about a third of a mile wide, to the south by the small Ambiri river, to the west by the Ipav and Yandev District boundaries and to the north by the road from Borgundu to Kaso opposite Igbon. The area was quite typical and included low lying marsh land with low rocky ridges of hills. The bush is of the savannah type with thick bush and large trees along the streams. For the last few years the area has suffered very badly from beetles and in 1927 it was probably the centre of the infestation.

The area consisted of five complete " village areas " and the greater part of a sixth, with a total number of 117 villages, *see* Table No. 6.

There were an average of 2,344 yam heaps per acre, built in rows with 189 heaps per 10 chains with the rows at 124 per 10 chains. Each farm is divided up into plots which are farmed by one woman, and each of such plots is marked by one " king row " of large heaps on which no water yams are planted. The average acreage of yam farm in the area was 3.2 acres per village and on the average each woman grew 0.85 acre of yams.

Roughly the total area under cultivation is three times that under yams, so that there were about twenty-four acres cultivated per square mile.

Analysis of Results.—The position of the farms with their percentage damage are shown in the map, and the average percentage damage of the groups of farms inside and around the area are shown in the map and Table No. 7. It will be seen that damage was most severe in, and to the north of, Kaso, but that in all directions the average damage was generally slightly worse outside the trial area. It will also be seen that there was no general increase of damage along the River Katsina.

As was to be expected it was found that farms in damp situations near streams had suffered much more damage than the farms in more arid situations even though they were near

marshland and rivers. The soil variations probably accounted for much of the sporadic distribution of severe damage. There was no correlation between size of farms and amount of damage.

In comparing the damage estimates the following two points have to be taken into consideration. The yam beetle is a powerful flyer and only on the eastern border of the area was there any considerable distance between the farms in and outside the area, there being normally about three quarters of a mile between the farms on the two banks. On the southern border there was probably nearly half a mile without farms, but on the west and north it was sometimes only a matter of a few yards between farms inside and outside the area.

Secondly there is the probability that the control method under trial will take two seasons to show the maximum effect. As has already been shown there are indications that a number of beetles live through the dry season into a second yam season. Of all beetles collected in the trial area thirty-eight *per cent.* were brown; of those collected in all parts outside forty-seven were brown.

As shown in Table No. 7 the average of the groups of farms inside the area shows 14.7 *per cent.* tubers damaged as compared with 19.3 *per cent.* outside. Although this decrease of the amount of damage by twenty-four *per cent.* is possibly indicative of beneficial results of the control method under trial, the experiment must be regarded as inconclusive. The value of this experiment was greatly impaired by the general decrease in the number of beetles in and around Tombo West.

In contrast to the variable " damage indices " found in and round the trial area the following results from Mkakor may be given. Sixty-four villages in the triangular area between Wunnune, Incha and Abor were examined. The average " damage index " was seventy-three and only two villages gave an index under 50, (49 and 38).

Although the actual result of the trial is inconclusive it was of value as it showed the possibility of enforcing simple control methods among the small farmers in a pagan district. There was some difficulty in getting the farmers to sow early but that was mainly because they had not enough warning to prepare the land in time. The farmers have, however, appreciated the results of the early sowing, as the growth of tubers was very good. The largest tuber seen was five feet long, and several of this size were grown on one farm.

There was little difficulty in enforcing the scattering, but opinion varied as to its results on the gero crop. Many farmers were very pleased with the results and apparently have decided to adopt the innovation in future. Others said they had poor yields of gero but that they hope to succeed with the method after a few years' trial. A few were definitely antagonistic. The District Head appeared pleased with the results and it is hoped to have the trial repeated in 1929 with all arrangements left in the hands of the Native Administration. A few farmers outside the area, having heard of the method of scattering, tried them voluntarily, and in any future experiments the difficulty will be to have a good control belt around the selected area.

LIGHT TRAPS.

The efficiency of light traps consisting of hurricane lamps standing in bowls of water seems to be poor as was shown earlier in the paper.

LEMON GRASS AS DETERRENT.

A test was made to see if lemon grass, *Cymbogon* sp. planted with yams acted as a deterrent.

In a quarter acre block of yams on the Plantation alternate rows of yams were planted with the grass which was planted close to the yam vine.

Analysis of the harvested yams gave the following results, showing no beneficial result.

Average *per cent.* of tubers damaged on control rows, 14%.
Average difference of rows with lemon grass, +3.2% ±5.4%.

EARLY SOWN TRAP CROP.

A trial was commenced on the Abinsi school farm of an early sown yam trap crop but the experiment was not concluded owing to the abandoning of the school. It seemed, however, that such a trap crop was impracticable owing to the late arrival of many beetles in the farms.

SUMMARY AND CONCLUSIONS.

The main features of the beetle attack in the Benue Province in 1928 were the great diminution in the number of beetles and the movement westwards of the centre of the infestation. There are also indications of movements of the epidemic in the Kukuruku Division. It seems likely that the pest becomes serious in a district only for a few years and then moves on.

There is now no longer any serious food shortage in the Munshi country but even if the epidemic does not return it will be some time before the yam cultivation returns to normal. Many farmers still have difficulty in obtaining sufficient seed yams.

An extensive breeding ground has been discovered along the Niger between Onitsha and Idah, and the larval habitat elsewhere is likely to be restricted to localities where moisture conditions are suitable through the dry season. It is possible that there is considerable migration of adult beetles from definite breeding grounds.

Search for breeding grounds along the rivers of the Benue Province will be made next season and until further data is obtained no recommendations can be made. The trial of scattering yam heaps in Tombo will however be continued as full benefit of this possible control may not be marked until the second season.

In conclusion the writer wishes to acknowledge the valuable help of Messrs. James and Ward, Superintendents of Agriculture, stationed at Yandev, for their assistance especially during the inauguration of the Tombo trial.

TABLE No. 5.

Rainfall at Yandev Plantation.

	INCHES OF RAIN.		
	1927.	*1928.*	*1929.*
January	0	2.16	0
February	.58	0	0
March	.36	3.72	0.63
April	4.14	4.54	1.91
May	10.10	6.77	6.92
June	5.79	12.89	10.32
July	4.28	5.58	2.06
August	9.63	3.28	5.84
September ...	7.99	10.73	6.16
October	9.67	9.98	8.24
November	1.11	0.11	0.48
December	0.54	0.87	—
	54.19	60.63	

Table No. 6.

Distribution of Villages in Tombo Trial Area.

Village area head.	Total No. villages.	Villages growing yams in area.	Villages growing yams outside area.	Villages examined.	Yam acreage.
1. Kaso	40	29	2	22	46·3
2. Akenawe	16	15	0	14	65·0
3. Jogona	21	19	0	11	58·6
4. Agar	25	25	0	18	111·2
5. Jigbuma	7	5	0	5	11·4
6. Gberogh	8	8	0	6	32·2
Total	117	101	2	76	324·7

Table No. 7.

Summary of Tombo Trial: Summary of "Damage Index" Determinations.

A —In the area.—

Village area.	Average index.
Kaso	24
Akenawe	11
Jogona	11
Agar	12
Jigbuma	10
Gberogh	8

Average 14·7

B.—Around the area.—

District.	Average index.
1. Ugondo & Tombo E.	24
2. Tombo E. (south) ...	14
3. Tombo W. (south) ...	16
4. Mbagen (south) ...	13
5. Yandev & Mbagen ...	13
6. Tombo W. (north) ...	29

Average 19·3

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SHEANUTS AND SHEA BUTTER.

BY

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I.—INTRODUCTION.

Overseas trade in shea products, at one time the principal export from Northern Nigeria, has failed to reach the dimensions which, with the advent of road and rail development, were prophesied for it; and whilst the last twenty years have seen a gradual expansion in the exports of other Nigerian oil-seeds, shipments of shea products, despite large fluctuations from year to year, have, on the average, remained practically constant. Thus, whilst the average annual export of palm-kernels has risen from 166,000 tons for the period 1908-1914 to 221,000 tons for the years 1920-1926, the corresponding figures for shea products are 6,704 and 7,014 tons, and the export in 1909 of 10,036 tons has only once been surpassed, and that by a matter of fifty tons in 1915. The small demand which has been primarily responsible for this lack of development has been due to the properties of shea butter.

Sheanut oil, or shea butter, is manufactured commercially either by crushing dried shea kernels (the shea " nut " of commerce) or by refining native-prepared butters. (cf. Part II). Native butter has a large local consumption, but exports are small. Buyers have been discouraged by the amount of adulteration that takes place at big buying centres, and losses were so heavy in 1924, when exports reached 735 tons, that certain exporters have since refused to handle it.

The refined fat is white, of a firm consistency and a not unpleasant odour and taste. Its " keeping " properties are also good, hence it finds use as an edible fat. Sheanut " oleine ", composed of the lower-melting glycerides, is employed in the manufacture of margarine and baking-fats; the " stearine " is used as a cocoa-butter substitute, whilst a hydrogenated " stearine " is similarly employed. The fat is characterised, however, by the presence of an unsaponifiable constituent, which may vary in amount from 2.5 to twelve *per cent.* although the usual limits are five to eight *per cent.* This unsaponifiable matter is present in the kernel of a freshly picked sheanut as a sticky white latex which may also be obtained by tapping the tree. A considerable trade in coagulated shea latex (shea gutta or red rubber) existed at one time in the Bornu Province: a sample examined in 1917 by the Imperial Institute (1) was found to contain roughly twenty-five *per cent.* of gutta and sixty *per cent.* of resin, and its value as a plasticising agent in the manufacture of rubber compounds, for which purpose it is slightly more valuable than pontianac, was assessed by a manufacturer at 1s. 3d. per lb.

A fat containing such a large quantity of unsaponifiable matter is of little value to the soap-maker except as a filling for softer soaps. As a result, edible-fat manufacturers can dispose of acid shea butter only at low prices. Manufacturers, at any rate in Great Britain, have also had scruples against the inclusion of such a compound as shea gutta in edible fats. Their prejudice against its use has been strengthened by the belief that unsaponifiable matter is eliminated in the native preparation of shea butter, a belief apparently not dispelled by the publication of analyses of native and solvent extracted fats containing practically the same amounts of unsaponifiable matter; (2) accordingly, this Department has been repeatedly assured that sheanuts could find no regular market unless some means of reducing their unsaponifiable content were discovered, and it has received countless suggestions for achieving this end. Variation in unsaponifiable content has, on no evidence, been ascribed to the existence of different varieties of shea tree, and schemes for weeding out the undesirable varieties have been proposed. It is unnecessary to add that whilst this would be a difficult enough operation with a plantation crop it is highly impracticable with a " bush " product.

Interest in sheanuts has quickened considerably during the last few years, no doubt partly due to the prominence they were given at the time of the Empire Exhibition. (3). Medical pronouncement that shea gutta is probably unabsorbed in the alimentary canal and the proposal of the Imperial Institute to prove this by a series of experiments have probably been causes contributory to the increased demand. Manufacturers no longer complain against unsaponifiable matter but against the great irregularity of shipments, both in quality and quantity.

The first requirement of edible-oil seeds is low free acidity, the loss on refining oils being roughly twice their F.F.A. It is desirable, therefore, that sheanuts should reach the home market with an F.F.A. less than six *per cent.* The oil-content should be high, and constant within narrow limits; although oil-contents as wide apart as forty *per cent. and* fifty-five *per cent.* have been recorded for commercial consignments, the usual range is from forty-five to fifty *per cent.*, and a standard of forty-six *per cent.* has been adopted in Brokers' Regulations.

A certain degree of variation between different consignments is to be expected, for sheanuts are purchased from the Ilorin, Niger, Benue, and Zaria Provinces, each of which employs a different method of preparation. The extent of this variation may be judged

from the experiences of a firm of manufacturers who report that in 1925 they bought consignments in England on one or other of the following bases :—

(*a*) Oil-content of forty-five *per cent.*, with premium or allowance of 5s. on contract price for every one *per cent.* of oil above or below forty-five *per cent.*

(*b*) F.F.A. of ten *per cent.*, with premium or allowance of two *per cent.* of contract price for every one *per cent.* of F.F.A above or below ten *per cent.*

In both cases they had to pay the agreed premium yet lost heavily, for nuts bought on an oil-content proved to be highly acid, whilst those bought on the standard of acidity had a low oil-content.

A fat which is to find regular use must also be available in constant quantity. Reference has already been made to the large fluctuations of exports from year to year. The crop has bad years such as 1927 when, despite keen competition for purchase, the total exports were only 3,000 tons. The harvest varies not only from year to year but from place to place, and a few miles may separate a district with a record harvest from one where the crop has failed.

The low price offered to the native is at present the great stumbling block to the development of the industry, and since manufacturers are agreed that the standard of exports must be raised before any increase in price is warranted, a tour of the Ilorin, Niger, and Zaria Provinces was made, in the fruiting season of 1928, in order to report on factors causing variation in the crop, and on possible improvements in the various methods of preparing kernels for export. Details of the native manufacture of shea butter were also collected.

II.—THE SHEA TREE.

The shea tree, *Butyrospermum parkii*, abounds between the latitudes of Lokoja and Kano, and is one of the most prominent features of the " orchard-bush " which lies to the north of the palm-belt. Outside this area the tree appears unable to thrive; a plantation in the South, at Olokemeji (4), has died out, whilst trees north of Kano are either barren or very uncertain yielders. Under favourable conditions the tree grows to a height of over fifty feet, and its general appearance and leaf-shape recall the English oak. Whilst the tree is hardy, and peculiarly resistant to the annual

bush-fires to which it is exposed, the stunted and often deformed tree of the uninhabited bush is a markedly inferior bearer to trees growing in areas that have been cleared for some years.

The tree begins to bear at twelve to fifteen years, and reaches full bearing capacity at twenty to twenty-five years. Clusters of heavily scented yellow flowers, with a strong attraction for bees, form on the tips of the leafless branches in January to March, and are immediately followed by the leaves. There is often a difference of several weeks between the flowering-dates of neighbouring trees, and it seems unlikely that this difference is varietal since it has been observed between trees with apparently identical fruit and leaf characteristics; further, the same tree may bear late one year and early the next.

Factors Affecting the Crop.

The following factors influence the date of flowering and determine the size of the crop.

(*a*) *Bush-fires.*—In experiments carried out on the Gold Coast (5), it has been shown that bush-fires cause serious damage only if the tree is in flower, when shedding results. Trees which have not begun to flower, or which have, on the other hand, already set fruits, suffer very little, although the date at which the fruit matures is probably affected. The time of year when the bush is fired depends on the date on which the farmer has been able to lift his last year's crop; late bush-fires are unusual in the Ilorin Province, but further north it is a common practice to burn the bush in February and later. Early bearers would thus be affected in the south, late bearers in the north.

(*b*) *Climatic conditions.*—The tornadoes of the early rains are probably the tree's worst enemy. They spring up towards the end of March in the Ilorin Province, and may occur as late as May in Zaria. In view of their localised nature and the fact that they remove both flowers and fairly big fruits, it is believed that they are largely responsible for the big variation in crop sometimes found between districts only a few miles apart.

The incidence of the rains, apart from its possible effect on the composition of the fruits, decides the time of bush-fires.

(*c*) *Cultivation.*—It has already been remarked that the biggest and heaviest bearing trees are to be found in sites that have been cleared for some years, *e.g.*, around native farms and in Rest

House compounds. Such is the only cultivation the tree receives. Since the shea area is much more sparsely populated than the palm-belt, and villages and farms consequently fewer, it follows that the shea tree receives far less adventitious cultivation than the oil-palm. The tree is regarded as an asset, for aliens are in some parts required to make payment to the village-head for collecting fruits, yet the treatment it receives compares very unfavourably with that extended to the oil-palm. There is no practice analogous to the rough pruning of palms, no attempt being made to remove the epiphytic "*etu*", (Hausa. "kauchi") which may ultimately kill the tree. Many trees are damaged by the careless removal of bark for medicinal purposes from the east and west sides, and the number chopped down to build houses would be greater but for the protection placed on the tree by the Forestry Department.

The beneficial effects of cultivation, obvious to a casual observer, are being demonstrated by experiments conducted on the Gold Coast. But if cultivation is not carried out in the butter-making centres, where the value of the tree is most fully recognised, it is a far cry to cultivation in those parts of Nigeria where the nut has at present such little value that the bulk of the crop lies uncollected.

(*d*) *Insect Attack.*—Whilst various pests have been reported from time to time as destroying the crop over small areas, *e.g.*, one was said to have ruined the crop in the north-west Provinces in 1911, one insect deserves special mention since it is of such permanent institution as to rank as a staple article of diet. This is the "*mani-mani*" of the Nupes, which denudes the tree of its foliage, usually after the fruits have fallen. This insect is widespread throughout the Niger Province. Eggs are laid at the leaf axils, and the black and yellow larvæ eat from the base to the tip of the leaf, leaving only the ribs; over forty caterpillars, covering practically the whole of its area, were seen on a single leaf. When they have stripped one tree they migrate to the next.

Further information is required on the effects of defoliation upon the host plant; it seems very unlikely that the tree can be unaffected by such sudden and violent derangement of the processes of assimilation and respiration. In a normal dry season the old leaves are shed just before flowering commences, whereas a tree stripped of its leaves in July develops new foliage in the following month. Records of its subsequent behaviour will be interesting.

(*e*) *Overcropping.*—It is rare to find a tree yielding heavy crops in successive years, and a number of non-bearing trees were

pointed out as having borne heavily the previous year; one tree, laden with fruits, was said to have borne a similar load five years previously, and to have yielded practically no fruit in the interim.

The Yorubas also recognise a " male " tree which, they say, flowers but never fruits. This is not to be confused with *Lophira alata*, the male shea of the Hausa (" namijin kadai ") and Nupe (" kochiba ").

It will be seen that the above factors will readily account for variation in harvest from place to place and year to year, and for the fact that in any one place there is only a moderate proportion of heavy-bearers, even in a good year. Mr. H. W. Langworthy, then Assistant Resident, Bida, made a count over an area of $\frac{1}{4}$ square mile at Badeggi in 1911. The sixty-four trees, with girth exceeding twenty-four inches at three feet from the ground, which, with six saplings, made up the shea population, were bearing as follows:—

Profusely—nil; Moderately—3; Sparsely—55; No fruits—6.

It is, therefore, a difficult matter to estimate what tonnage of nuts would be regularly available for export, and the estimate of 260,000 tons of shea butter as the possible annual output of the Northern Territories of the Gold Coast appears highly optimistic.

III.—FRUIT CHARACTERISTICS AND COMPOSITION.

The shea fruit contains from one to four nuts, of which the sheanut of commerce is the kernel. Immediately under the tough apple-green skin is the mesocarp, a fleshy layer in which the nuts, consisting of kernel and endocarp (shell), are embedded. In an unripe fruit the mesocarp is tough and astringent, and the endocarp fairly soft and ivory-white. On ripening, however, the mesocarp develops sweetness and becomes so soft that it retains the impression of the fingers, whilst the endocarp hardens and changes through cream to golden brown. At this stage, usually reached in June to August, the fruit falls from the tree and is collected.

The mesocarp has a pleasant taste very reminiscent of Sapodilla, and is eaten by the pickers and their families. If left on

the ground it is stripped by insects within a few hours, the nut gradually darkens and, on moist ground, germinates in about a fortnight.

The majority of fruits contain only one nut, which is round to ovoid, or oval, according to the shape of the fruit. The percentage of apple-shaped double-seeded fruits, in which the nuts are flat-sided like a chestnut, was determined on random selections of 300 fruits at Iponrin and Bode Sadu, where the figures were 6.4 *per cent.* and 5.6 *per cent.* respectively. Fruits containing three or four nuts, shaped like a Brazil nut, are comparatively rare.

There is considerable variation between the shapes of single-seeded fruits; two types are distinct and recognised by the native, fruits of one type never being found on trees bearing the other.

Type I. Round.—Fruit round to ovoid and rarely furrowed. Mesocarp not very sweet. Pedicel fairly long.

Type II. Long.—Fruit relatively longer, oval to elliptical, often furrowed. Mesocarp very sweet. Pedicel short.

The types are widespread. The Yorubas and Hausas have no distinctive name for them, but Nupes are said to call Type II " kochi giddanchi ". The measurements included under Iponrin Round and Iponrin Long in Table I. are averages for ten ripe fruits from three trees of each type. It is not always easy to assign stripped nuts to one of the types, though the ratio $\frac{\text{Length}}{\text{Diameter}}$ is fairly distinctive, and the average values for this ratio as determined on a number of fruits from the Zaria, Niger, and Ilorin Provinces were :—

Round—1.24; Long—1.50.

A remarkable change in fruit size is to be noticed as one passes from south to north. On approaching the River Niger from either the Ilorin or Niger Province there is a falling off in the size of commercial nuts. Thus, whilst nuts from Badeggi (Niger) are slightly larger than those from Bode Sadu (Ilorin), the ones bought at Jebba, the centre of the river trade from Leaba to Lafiaji, are smaller than either, and are, in fact, the smallest that the writer has seen. The increase in size continues as one proceeds further north; Zaria nuts are bigger than those from Minna, which are themselves bigger than Badeggi nuts. This difference is to be seen by comparing the measurements for Shika (Zaria) and Iponrin (Ilorin) types given in Table I.

The change appears to be ecological, rather than varietal, and is probably intimately connected with water supply. (cf. p. 88).

Other varieties may exist. The tree varies in habit, both upright and spreading types being found, and Mr. A. G. G. Hill, of this Department, suggested that these types might represent different varieties. Fruits from two such trees, growing next each other, and not apparently deformed, were collected from Bakeko (Niger). Both trees were about thirty-five feet in height; the span of the upright tree was twenty-one feet, that of the spreading thirty-eight feet. Fruits from both were of the round type, but whilst those from the upright tree ended in a sharp point, the ones from the spreading tree had a small depression at the apex, similar to that found in an apple. Analyses of the various types for oil-content and unsaponifiable matter are to be found in Table VIII. It will be seen that there appears little difference in chemical composition between any except large and small types of fruit.

Specimens of leaves and fruits were collected with a view to having the types identified by Kew, but the problem of collecting flowers from the same trees has proved insurmountable.

TABLE I.

Type of fruit.		Weight in grammes.	Length in cm.	Diameter in cm.
Iponrin Round :—				
	Fruit ...	34.6	4.6	3.6
	Nut ...	13.6	3.7	2.9
	Kernel ...	11.0	3.5	2.8
Iponrin Long :—				
	Fruit ...	30.7	4.9	3.3
	Nut ...	14.6	4.1	2.6
	Kernel ...	12.3	3.9	2.3
Shika Round :—				
	Fruit	56.8	5.8	4.2
	Nut ...	22.3	4.5	3.3
	Kernel ...	18.4	4.3	3.1
Shika Long :—				
	Fruit ...	—	—	—
	Nut ...	21.2	4.8	2.9
	Kernel ...	18.0	4.5	2.7

Table II.

Average Composition of Ripe Fruits from Ilorin, Zaria, and Niger Provinces.

Type.	Number of fruits examined.	Percentage nut to fruit.		Percentage kernel to nut.		Percentage kernel to fruit.	
		Range.	Average.	Range.	Average.	Range.	Average.
Round ...	76	34·9–41·3	39·1	80·0–85·1	81·2	28·0–33·8	31·7
Long ...	52	43·1–47·6	46·2	78·7–86·2	84·1	35·6–40·2	38·9
Double ...	7	29·0–31·8	30·0	78·4–82·6	81·1	23·4–25·1	24·3

The percentage of nut to fruit decreases just before ripening, owing to changes in the mesocarp. Measurements were made at Juafu on ten ripe and ten full-sized hard fruits from the same tree. The figures were :—

Ripe.—Per cent. nut to fruit 47.6 *Per cent.* kernel to nut 84.3
Unripe.— ,, ,, ,, ,, 51.9 ,, ,, ,, ,, 83.6

IV.—PREPARATION OF KERNELS FOR EXPORT.

A freshly picked kernel contains from forty-eight to sixty *per cent.* moisture, and the removal of this water is, with one exception (cf. Munshi process, p. 96), the first step in the native preparation of shea butter. Both sun drying and artificial drying are practised, the former by Yoruba and Hausa, the latter by Nupe and Gwari peoples. The Yoruba process is in general vogue in the Ilorin Province, and on the northern boundary is to be seen side by side with the Nupe method in mixed villages such as Share; Jebba buys both sundried and kilndried kernels. With the exception of the environs of Minna, where Gwari kernels are found, the Nupe method is widespread throughout the Niger Province, as is the Hausa method throughout Zaria. The following are the various processess.

I.—SUNDRYING.

A.—Yoruba Process.

1. *Collecting.*—Pickers are abroad at daylight to collect fruits that have fallen overnight. Around butter-making centres there is keen competition for collecting and there are well defined paths in the grass round bearing trees. A man is said to be able to collect 100 lb. of fruit in one day, but the load brought in by women and girls after a morning's picking is usually from ten to twenty lb.

2. *Boiling.*—As much of the mesocarp as is wanted is chewed off by the pickers, or eaten by the family and sheep, and the nuts, together with any adhering mesocarp, are then boiled for an hour in an earthenware pot, usually within two days of collection. Boiling serves the following purposes :—

(i) It effectively cleans the nuts of mesocarp.

(ii) It kills the embryo, thus preventing germination, and inhibits enzyme action.

(iii) It causes a slight even shrinkage of the kernel, and so ensures that it shall not adhere to the shell during subsequent shrinkage.

The nuts do not appreciably change in weight during boiling.

3. *First Sunning.*—The nuts are then spread in the sun to dry. They are considered dry when the kernel, which has now shrunk considerably, makes a harsh rattle when the nut is shaken. At this stage, usually reached after five to ten days sunning, the nuts are sometimes sold to local butter-makers. At Iponrin a standard basket of dry nuts could be bought in late June for 6d. Such a basket contains from twenty to twenty-three lb. of nuts, according to the moisture-content of the kernels, which was found to vary from fifteen *per cent.* to thirty *per cent.* Wetter nuts are often bought, at a reduced price, if the butter maker finds difficulty in buying dry kernels or nuts.

4. *Cracking.*—The shell is brittle, from 0.2 to 1.4 mm. thick, and loose from the kernel; consequently cracking is easy, and broken kernels rare. Nuts are cracked either between two stones—by this method a girl can crack about thirty lb. of nuts and separate the kernels in an hour, or in a pestle and mortar, in which a man is said to be able to crack 250 lb. of nuts and winnow the kernels in a day. The former method gives fewer broken kernels, and is the one more frequently employed by the Yoruba, who usually handles small quantities of nuts at a time.

5. *Second Sunning.*—The kernels are next spread out to dry in the sun Given good weather they are ready for the next step in butter making after about five days sunning, when the moisture content has fallen to ten to fifteen *per cent.* But freshly cracked kernels, containing up to forty *per cent.* moisture, are readily bought by buttermakers at the beginning of the season when the heavy rains make dry kernels difficult to obtain. The bulk of kernels then offered for sale in the small markets are of this kind. When bought by the buttermakers they are immediately put out into the sun, and

made into butter within a few days of purchase. But in the early days of export such kernels were bought by European firms, stored in badly ventilated sheds, and often shipped wet, with disastrous consequences. (cf. p. 76). Even now it is difficult to impress on the native that the requirements of European buyers are different from those of the buttermaker.

Drying for Export.—Kernels for export require at least ten days intensive drying after removal from the shell, and should not contain more than seven *per cent.* moisture. The characteristics of well-dried kernels are :—

(i) A handful, when squeezed between the palms, shows no compression, and gives a high pitched rattle when shaken in the cupped hands.

(ii) A sharp fracture is produced by inserting a knife point a short distance into the kernel and twisting sharply.

(iii) A kernel cut at right angles to its length cannot be compressed by squeezing between the finger and thumb.

Table III gives the rates of drying of a selection of round and flat sided nuts (from double fruits) taken from a sixty lb. sample, already partly dried, whilst the drying rate of two samples of freshly peeled nuts is given in Table IV. Moisture contents were determined in both cases by the removal, at intervals, of ten nuts from a large sample of similar origin given the same treatments.

TABLE III.

Treatment.	Weight in grammes 20 flat nuts.	% water in kernels.	Weight in grammes 40 round nuts.	% water in kernels.
As bought	193·4	41·8	475·6	42·6
Sundried two days ...	169·8	31·5	422·6	33·8
„ four „ ...	145·6	14·6	367·4	19·8
„ eight „ ...	138·0	9·3	346·0	13·5
	Kernels.		*Kernels.*	
Cracked	96·3	9·3	243·0	13·5
Sundried eight days ...	92·1	7·8	228·6	8·1

	Flat.	*Round.*
Percentage kernel to nut at time of cracking	67·4%	70.2%

TABLE IV.

Treatment I.	Wt. in gr. 20 nuts.	% moisture in kernels.	Treatment II.	Wt. in gr. 20 nuts.	% moisture in kernels.
1. Freshly peeled ...	284·6	—	Freshly peeled ...	217·2	—
2. Boiled and wiped	283·1	61	Boiled and wiped ...	214·5	53
3. Sundried 5 days...	178·6	38	Sundried 10 days ...	149·5	27
	Kernels			*Kernels*	
Cracked	132·2	38	Cracked	111·2	27
Sundried 10 days	94·9	8·3	Sundried 5 days ...	90·7	10·8

	I	II
Percentage kernel to nut at time of cracking ...	74·0%	74·4%

As would be expected, drying in the shell is slower than drying cracked nuts.

B.—Hausa Process.

The actual processes in the Hausa preparation are the same as those of the Yoruba. There is not, however, the same eagerness on the part of the Hausa to collect fruits, and it is often a matter of some days before a pile worth boiling is obtained. During this time fruits are piled into heaps to induce fermentation of the mesocarp. Germinated nuts are a common feature of these piles, which are loose and do not develop sufficient heat to kill the embryo. Such nuts are also picked up when they have lain under the tree for some weeks.

II.—KILN-DRYING.

A.—Nupe Method.

1. *Collecting.*—Kiln-drying is essentially a large-scale process. The capacity of a kiln is from 150 to 200 lb. of dry nuts, and, owing to the scarcity of fuel, it is not economical to fire the kiln until the requisite quantity of wet nuts, 300 to 400 lb., has been collected. Whilst the time taken to collect such an amount is naturally dependent on the available crop, it is also determined by the amount of labour that can be spared from the fields.

The collecting season, June to August, coincides with the planting of groundnuts, cotton, sweet potatoes, and cassava, and with the harvest of bulrush-millet. The Northern farmer has learnt that neglect of his food crops through attention to cash-crops may lead to famine, a danger to which the Southern farmer, with his longer growing-season, is less exposed. This was the explanation invariably advanced when Nupes and Hausas were asked why picking was so dilatory.

In kiln-drying the poverty of the harvest is enhanced, the percentage of nuts left uncollected being noticeably greatest where the complaint against a bad season was loudest. Collection is apparently not attempted unless there is a prospect of effortless acquirement of a kilnful of nuts; no dealing in small lots was seen. The contents of several kilns in the neighbourhood of Badeggi were said to have been collected over a period of two months.

2. *Fermentation.*—Boiling is not practised. The whole fruits are stacked into heaps or buried in shallow pits to induce fermentation in the sugary mesocarp. It is very probable that the heat developed in successfully controlled fermentation is sufficient to kill the embryo; this point is worth investigation. Germinated nuts were quite common, but, as in Zaria, numbers were being picked after lying on the ground for some weeks.

3. *Baking.*—After fermentation, the fibrous residue of the mesocarp is easily shaken from the nuts, which are then baked. Kilns, a characteristic feature of Nupe villages, are about 4½ feet high, mortar-shaped, and made of mud. They are covered by an overhanging grass roof. The nuts rest upon a perforated mud grate which, raised about a foot from the ground, divides the kiln into heating and drying compartments. A slow-burning piece of wood is pushed through a single opening in the base of the kiln, and allowed to smoulder night and day. The heat developed is very moderate, and of six kilns examined the hottest was 90°C. at the grate, and 60°C. at the surface, whilst the average temperature gradient was 80° to 55°C. Drying is continued until the surface layer is adjudged dry, usually after four to five days and nights; little attempt is made to hasten drying by stirring the nuts.

4. *Cracking.*—The nuts are cracked either in a mortar or between stones, and the kernels are then ready for sale to the stores. The moisture content is in the neighbourhood of six to seven *per cent.*, and is not significantly different from that of well-sunned kernels.

B.—Gwari Process.

The method followed by the Gwaris is the same as that used by Nupes, though the kiln is of different construction.

A cylindrical mud body, about three feet high, rests on four legs which raise it about a foot from the ground. The base of the cylinder is filled in with a framework of crossed sticks set into the walls; the nuts rest on this framework. The kiln is built inside a hut used for drying grain; cobs of corn are placed on top of the nuts

(the kiln holds about 100 lb. of dry nuts), and bundles of gero are hung round the walls. A smouldering piece of wood is placed under the grid, and a very gentle heat, about 50°C., is produced in the middle of the mass. Moderation in heating is called for by the danger of the wooden grid being burnt.

Drying is complete in about ten days and nights.

V.—FACTORS AFFECTING THE QUALITY OF KERNELS.

It is obviously of prime importance to decide whether any of the native methods of preparation gives kernels superior in respect of manufacturers' requirements, which are, as we have seen, low free acidity and high oil-content.

I.—Free Acidity.

Acidity arises by the breakdown of a fat into its components, glycerine and fatty acid. This process, known as hydrolysis, demands the presence of water, and a catalytic agent is also necessary if the reaction is to proceed quickly. Such catalysts are lipolytic enzymes, bacteria, fungi, and certain chemical compounds, which may be originally present in oil-seeds or arise by subsequent treatment or contamination.

Development of Acidity in Uncracked Nuts.

The generation of free fatty acid in nuts with undamaged shell is very slow, even when they have been stored wet and no immediate steps taken to inhibit enzyme action. This is to be seen from Table V. Sample 3 had been piled up wet and exposed to the rain for a fortnight before being boiled; it was then bagged wet, and only able to dry slowly. Sample 4 was taken from a collection of Nupe nuts which had been piled up for two months, then kiln dried.

Table V.

Material.	Treatment.	Sampled.	Examined.	Moisture kernels.	F.F.A. % oleic acid.
1. Fresh nuts (Iponrin) ...	Boiled, sundried 20 days, bottled ...	June	September	7·27%	0·3%
2. Fresh nuts (Biri-Biri) ...	do. do. do	July	November	7·33%	0·4%
3. Hausa-dried nuts (Samuru)	Stored wet in porous bag	July	November	9·43%	1·6%
4. Nupe-dried nuts (Juafu)	Bottled	August	October	6·91%	1·4%
5. Fresh nuts (Bakoko) ...	Boiled, bottled wet ...	August	November	34·1%	5·7%

Provided that the nuts are not stored under conditions favourable for germination (cf. p. 77) there is, therefore, no serious objection to the practice of storing nuts for several weeks prior to kiln drying.

Development of Acidity in Sundried Kernels.

Whilst kiln-dried kernels are not removed from the shell until dry, in sun-drying the kernels are exposed to contamination when the water-content may be as high as forty *per cent.* It is possible to dry out wet kernels without causing a big increase in F.F.A. if drying is performed immediately. Of four samples of butter-makers' kernels examined just before conversion to butter, the most acid had an F.F.A. of only 0.65 *per cent.*

But moist nuts stored under conditions of bad ventilation rapidly become acid, fermentation, with subsequent growth of fat-splitting moulds, having set in. Faulty storage has been the chief reason for the high acidity of commercial consignments.

The bulk of sun-dried kernels offered to the canteens, particularly at the beginning of the buying season, which coincides with the rains, satisfy butter-makers' requirements, but are unsuitable for storage and export. In the absence of competition it is possible to send such kernels back for a further period of drying or, if the store possesses a drying floor, to persuade the owner to leave her kernels to be dried by the store, and return for payment when the nuts have been measured, in a few days' time. But this course is rarely possible. Kernels are usually brought to the big markets by middlewomen who have not collected the kernels they offer, and whose only aim is to realise ready money to allow them to do further trading in the markets.

Bode Sadu, the biggest buying centre for sundried kernels, may be cited as an example. Three European firms are represented by native buyers, and there is, in addition, a big native market where butter-makers and middlemen buy. On market days quantities of wet kernels are offered to the stores, and a large proportion of rejected kernels find their way to the middleman, who buys wet kernels at a lower price than that paid by the canteens.

At present these middlemen constitute a serious menace to the industry. Their accommodation usually consists of a small lock-up store in which wet kernels are piled three or four feet high. It is the object of the middleman to resell the kernels to the stores at the

end of the season, when he counts on an increase in price to make his profit (cf. p. 82). He makes, therefore, no attempt to dry the kernels quickly, an occasional turning over being the only treatment they receive. Consequently such kernels rapidly become acid.

A 14 lb. sample of middleman's kernels, moisture-content thirty-seven *per cent.*, was divided into two. One half (1) was dried in the sun, the other half (2) allowed to dry out slowly. Both were analysed two months after sampling.

1. Water-content	... 6.75%	F.F.A. (oleic)	3.26%
2. Do. do.	... 6.50%	do do.	8.99%

Again, when the store buyers have seen the early crop diverted to the middleman and have received no dry kernels in the canteens, they begin to fear that they will get no tonnage, and are tempted to buy kernels that they know to be wet. This had happened in two of the three stores in Bode Sadu, where soapy kernels, containing roughly eleven *per cent.* of water, had been purchased and were being regularly turned over in the hope of drying them before the impending visit of the European agents. Neither store had a drying floor, and whilst one had sliding doors which would have materially improved ventilation, they had not been opened.

A 14 lb. sample from one of the stores was divided into two, one half (1) sun-dried for twenty days, the other half (2) allowed to dry slowly for four weeks under conditions better than those obtaining in the store, then sun-dried and bagged. At the end of three months the analyses were :—

1. Water-content	... 6.39%	F.F.A. (oleic)	3.15%
2. Do. do.	... 6.69%	do. do.	3.73%

Apart from chemical analysis there is no simple means of deciding the past history of kernels. On drying out, fermented kernels lose the bloom which covers them during fermentation. Unless the stores are to buy back quantities of doubtful kernels from the middleman, it is, therefore, essential that they try to secure as big a proportion of the early crop as possible. In the present state of development of the industry the simplest method of attack would appear to involve the provision of drying floors, and the purchase of both dry and wet kernels, the latter at considerable discount, *e.g.*, at middleman's price. It is believed that under this system the native might be tempted to dry more thoroughly in order to secure the higher price. At present the seller of dry kernels is

unfairly penalised, for the agent has to allow a margin for loss on shrinkage far greater than the shrinkage of dry kernels warrants, merely as a safeguard in case his buyers should accept wet kernels. It was reported that one firm had already made a move in this direction by putting a native into the market to buy at middleman's price. It is only doubted whether drying would be carried out well enough to take full advantage of this step. An elaborate shed with a sliding roof is not necessary. Spreading the kernels in a thin layer on sheets of corrugated iron during the day time, and on the floor of the store at night, until they were thoroughly dry, would amply repay the trouble involved.

It is easy to differentiate between kernels which are dry and those nearly dry, whilst an experienced buyer can roughly assess the moisture in wetter samples. Thus, an experienced Nupe buyer at Jebba was able to place in correct order of wetness four samples containing from 6.9 *per cent.* to 10.5 *per cent.* moisture. It also seemed probable that the weight of a standard measure of kernels would afford fairly reliable indication of their water-content. The weight of a heaped bushel of kernels (the measure by which the bulk of kernels are sold) was found to vary, at Jebba, from 52 to 55 lb., and samples weighing over 52 lb. were in every case declared wet by the buyer and on analysis were found to contain over seven *per cent.* moisture. Before this method could be recommended a very large number of samples would need to be examined, for there is probably a great amount of variation in the weight of different samples of kernels with the same water-content, especially if collected from different localities. There were no dry kernels at Bode Sadu that could be tested; the kernels with a moisture-content of eleven *per cent.* already mentioned, weighed 55 lb. to the heaped bushel.

Changes on Germination.

During the process of germination the oil stored in a seed is broken down into simpler compounds available for the growing shoot. The first step in this degradation is hydrolysis, carried out by lipolytic enzymes contained in the seed. The first effect of germination, therefore, is an increase in free acidity and a decrease in oil-content. A secondary effect arises, for on germination the shell is punctured at a time when it is usually lying on wet ground. Rapid deterioration continues after the seedling has died. Practically all the germinated nuts found in piles were covered with a thick growth of black mould. It will be seen from the following analyses of germinated nuts how strongly the practice of collecting germinated nuts is to be deprecated.

Germinated Nuts.

Source.			% oil on dry weight of kernels.	F.F.A. (oleic).
1. Tree.	Biri-Biri	... ...	38.5%	9.8%
2. Pile.	Samuru	... ...	36.3%	11.4%
3. Kiln.	Bakeko'	... ...	39.5%	7.2%

2.—Oil-Content.

Whilst roasting kernels causes a loss of oil (cf. p. 92) no loss results from the gentle baking they receive on kiln-drying whilst still in the shell. The loss of oil on germination has already been noted. Analyses of commercial samples of both sun-dried and kiln-dried nuts are given in Table VI. It will be seen that No. 5, the Hausa sample is the only one that would not satisfy trade requirements, since the oil-content is less than the prescribed forty-six *per cent.* Low oil-content and high percentage of unsaponifiable matter appear to be characteristic of kernels collected from the Zaria Province. (cf. also Table VIII.).

TABLE VI.

Commercial Kernels.

Preparation.	Source.	Percentage Water.	% oil on dry weight.	% oil as received.	F.F.A. (oleic) after storing in bags three months.
1. Yoruba	Jebba ...	7.36	51.8	48.0	2.71%
2. Mixed	Jebba ...	7.89	52.4	48.3	3.76%
3. Yoruba	Bode Sadu	6.39	51.9	51.2	3.81%
4. Yoruba	do. ...	7.10	46.1	48.2	2.17%
5. Hausa	Zaria ...	7.87	52.6	42.5	2.75%
6. Gwari	Minna ...	5.86	52.6	49.5	3.72%
7. Nupe	Badeggi ...	6.37	52.2	49.3	4.33%
8. Nupe	Juafu ...	6.84	54.7	48.6	3.92%

Changes on Storage.

1. *Shrinkage.*—Although enormous shrinkage losses may be suffered if improperly dried kernels have been purchased, (cf. p. 82) thoroughly dried kernels actually gain in weight when stored in the wet season. Where samples taken for analysis had been divided, part bottled and the other part bagged, the bagged sample had invariably a higher water-content than that of the bottled one.

Samples of Gwari, Yoruba, Nupe, and Hausa prepared kernels were confined over thirty-three *per cent.* sulphuric acid, *i.e.*, in an atmosphere of roughly seventy *per cent.* relative humidity, to determine whether the amount of moisture reabsorbed were dependent on the method of preparation of the kernels. With kernels whose moisture-content had been reduced to five *per cent.* by prolonged drying at 40°C. an initial absorption was recorded in every case. The experiment was vitiated, however, by a growth of mould on the Hausa kernels, which, after a preliminary increase in weight, began to lose weight steadily, with evolution of carbon dioxide. This loss continued even after the moisture-content had been artificially reduced to four *per cent.*, and the infection finally spread to the other samples before they had attained constant weight.

The experiment was then repeated with a fresh batch of samples which had been heated at 80°C. for six hours in an attempt to kill off the growth on the Hausa kernels. Moisture-contents were determined before heating, on parallel samples. The kernels were placed in the absorption chamber, care being taken to separate the Hausa kernels from the rest, and their weight was determined daily until equilibrium was reached. The samples were then allowed to stand a further three months, reweighed, and their moisture-content determined. The results are appended in Table VII.

It will be seen that the Hausa kernels again lost weight, and that this loss is not accounted for by loss of water, which, allowing for a fairly big sampling error, explains the change in weight of all the other samples.

It is obvious from these results that there is little danger of the moisture-content of kernels stored under the conditions prevailing in the collecting season falling much below six *per cent.*, and unless fermentation takes place, shrinkage losses should be small.

TABLE VII.

Kernels.	Original sample.		Dried at 80° C.		Time taken to reach equilibrium.	At Equilibrium.		After standing 3 months.	
	w.	m.c.	w.	m.c.		w.	m.c.	w.	m.c.
Hausa ...	164·8	7·89*d*	158·2	4·03*c*	Never reached	...	...	154·9	2·06*c* 6·21*d*
Yoruba ...	190·2	7·87*d*	184·1	4·82*c*	18 days	186·74	6·16*c*	186·69	6·14*c* 5·93*d*
Nupe ...	178·6	6·37*d*	174·2	4·01*c*	23 days	176·32	5·16*c*	176·12	5·05*c* 5·94*d*
Gwari ...	181·0	7·31*d*	175·6	4·77*c*	21 days	179·51	6·54*c*	179·50	6·54*c* 7·00*d*

m.c. = moisture content. d. = determined.

c. = calculated on assumption that change in weight is due to loss or gain of water.

w. = weight in grammes.

2. *Change in F.F.A.*—One firm of exporters told us that they usually calculated on an increase in F.F.A. of one *per cent.* for every month of storage. This figure is probably representative of the change on storing moist kernels up to the point of dryness, but is too high for dry kernels. A sample of fairly moist kernels was stored at Ibadan for a year. At the end of that time the kernels had an F.F.A. of 7.8 *per cent.*, and a moisture-content of 9.08 *per cent.* The determinations of F.F.A. given in Table VI were made on 14 lb. samples that had been stored in bags for three months in order to form some idea of the acidity they would have had at the time of shipment. 14 lb. samples of each type were also nailed up together in a kerosene case with the intention of making monthly determinations of F.F.A. Unfortunately the whole of the samples were destroyed during the first month by the larvæ of a small black moth.

Despite the lack of the conclusive evidence that this experiment would have afforded, there appears no reason why any of the samples examined should arrive home with an F.F.A. greater than six *per cent.*

VI.—KILN *versus* SUN-DRYING.

Conclusions.

1. There is no immediate superiority of kiln-drying over sun-drying, or *vice versa*, provided the following conditions are observed.

Kiln-drying.—

(*a*) Germinated nuts should not be collected from the ground.

(*b*) Preparation prior to baking should kill the embryo. If fermentation is found not to achieve this, boiling is to be recommended.

Germinated kernels are readily recognisable by their " tails ", and buyers should refuse to handle parcels containing a large proportion of such kernels.

Sun-drying.—

(*a*) Drying in the shell should proceed as far as possible.

(*b*) Drying of kernels should be performed as rapidly as climatic conditions allow. Stores should be provided with drying floors, and in the event of competitive buying should be empowered to buy wet kernels at a discount, and carry out their own drying.

2. Both processes, if properly carried out, give a product which satisfies manufacturers' requirements, arriving home with an F.F.A. less than six *per cent.*, and an oil-content greater than forty-six *per cent.* Kernels from Zaria Province appear exceptional in possessing a low oil-content.

VII.—MARKETING.

1. *Ilorin Province.*—It has already been mentioned that, of the sun-dried kernels offered in the big markets, very few are brought by the actual collectors. Numbers of women traders engage in buying kernels in the villages and bringing them to the buying centres.

The price in the villages is usually fixed by the demand from the buttermakers. Since the native demand for shea butter is fairly constant, the maker can raise the price of butter, and pay correspondingly high prices for kernels in a time of scarcity. Kernels are bought by a standard-sized basket, which contains from 25 to 30 lb., according to the moisture-content of the kernels. In 1927, a bad year, at Iponrin such a basket fetched 1s. 6d. in June, and 2s. in September, the corresponding prices in 1928, an average year, being 1s. and 1s. 6d. At Odetunde, a buttermaking village roughly two miles from Bode Sadu, a slump in butter, then selling at 1d. to 1½d. per lb., had brought down the price to 6d. in July, 1928. At this time middlemen were offering 1s. per quarter for wet kernels in Bode Sadu market. Women traders are not slow to seize on differences much less than this, and will carry kernels big distances for profits, which, after the kernels have been dried out, are often nebulous. Thus, a case was observed at Jebba where a woman, who had bought wet kernels by the cash-bowl in Bashita market and dried them herself, had walked eight miles to make a profit of 1½d. on a quantity of kernels which had been head loads for herself and two small girls. This is typical of the narrow margin existing between store and native prices. The store price at this time was 2s. 3d. per heaped bushel, and this particular woman said she would bring no more kernels to the store; with a price of 2s. 6d. she would have been perfectly contented. As the tonnage collected had been small the store price was actually raised to 2s. 6d. towards the end of the season, but in the meantime the buttermaker's price had been pushed up by the falling off in supply.

Except in years of very heavy crop it is essential that the store price should be at least 3d. per bushel higher than the native price, and a bigger advance in the middle of the season, when

supplies are more plentiful and the quality more reliable, would be warranted. Given an attractive margin, middlewomen can be relied on to bring kernels up to twelve miles in bush country, and further distances if motor or canoe transport is available.

The middleman's price of 1s. per quarter corresponds very closely to the buttermaker's price of 1s. per basket, and it will be shown that after drying his kernels he would make no profit on selling at 2s. 3d. per bushel, the prevailing price in Bode Sadu at the time, and very little profit if he sold to the one store that was offering 6s. per cwt.

A representative sample of middleman's kernels was weighed, thoroughly sun-dried, then reweighed.

Weight of original sample 421.0 gr.Moisture-content 37%.

Weight of original sample after drying 285.9 gr. Moisture-content 7.1%.

Price paid for one ton at 4s. per cwt. = £4 0s. 0d.

Price realised after drying (6s. per cwt.) = £4 1s. 6d.

At the end of September the store price had been raised to £6 12s. 6d. per ton, so that he would realise £4 10s. for his original ton of wet kernels. This is putting his profit at a minimum, for, although the sample taken was representative of his day's purchase of 4 cwt., it was taken at the beginning of the buying season; kernels bought later would not show the same shrinkage.

Comparatively few nuts are left uncollected. Germinated nuts were seen :—

1. In districts which lay outside the collecting range of villages.
2. In inaccessible places—in thorny bush, etc.
3. Under trees which had borne considerably later than the rest, and were sufficiently isolated to render collection unprofitable.

2. *Niger Province.*—Kiln-drying involves the collection of such a large quantity of nuts that kiln driers are in a position to make butter or sell their kernels to the stores without the assistance of the small trader.

The Gwaris almost entirely dry kernels to sell to the canteens, whilst the course adopted by the Nupes depends on the prevailing price of butter, and on the available labour. It has already been stated that the Nupe requires great inducement to keep him from the fields during the early season. In early August the stores were

offering 2s. per heaped bushel for kernels, whilst the native price for butter was 2½d. per lb. At this figure a profit of at least 9d. could be made by turning a bushel of kernels into butter. Although this would have been an attractive profit to a Yoruba maker, many Nupes considered it not worth the trouble involved. The few who were making butter were prepared to pay higher prices than the stores for kernels, *e.g.*, 2s. 4d. per bushel when the store price was 2s., and 2s. 8d. per bushel when the store price had risen to 2s. 3d. in September.

3. *Zaria Province.*—A very small proportion of the crop is harvested, and exports in the past have rarely exceeded a few hundred tons. This is due partly to the scarcity of buying centres and to the big distances between villages, but most particularly to lack of interest. 1928, however, was a year of record crop, and over 3,000 tons of kernels were exported from the Province. This must represent a small proportion of the total crop, for germinated nuts could be seen under most trees. The manufacturers' report on these kernels will be received with interest, as it appears that they may be inferior to those collected further south.

The price offered by the stores was the same as that paid in the Niger Province, *i.e.*, 2s. 3d. per bushel, roughly £5 per ton, towards the end of the season.

VIII.—DEVELOPMENT.

The preparation of kernels for the market is neither skilled nor arduous. But the marketing of a bushel of kernels involves the collection of 300 lb. of fruits, which, with average competition for picking, will occupy a woman for at least ten mornings, and may mean headloading a weight of 50 lb. for distances up to twelve miles. Two shillings is bare recompense for these operations alone, and a considerable increase in price is necessary before the industry is rendered attractive to the native.

Low prices have been determined in the first place by a limited home demand, but the policy of the local buyer is not above criticism. His firm usually quotes him the limiting price that can be paid for dry kernels. Realising that he may be faced with heavy shrinkage losses if his native buyers have accepted wet kernels he allows a big margin of safety, *e.g.*, he pays £5 per ton when quoted a limit of £7 per ton. In years of moderate crop this brings his price below that of the buttermaker, and leads to a large proportion of the crop remaining uncollected, and to deterioration in quality, due to dilatory picking, in the portion harvested. The practice of holding down to a low price through the most plentiful time of harvest, and

increasing it only at the end of the season, encourages the hoarding of supplies by middlemen and the collection of nuts left on the ground at the time when the price was not sufficiently attractive.

It will usually be found that where low prices (£4 7s. to £5 per ton) are being paid, only one firm is represented, and to judge the value of the produce to the exporter one has to turn to centres where competition exists. Around Ilorin in September, 1928, two competing firms had raised their price to £6 15s. per ton. This must be considered generous, as it is comparable with local prices for oil-seeds which have a much wider application and more constant demand. This is seen from the following prices.

PRICES, OCTOBER, 1928.

PALM KERNELS.	£	s.	d.	SHEANUTS.	£	s.	d.	GROUNDNUTS.	£	s.	d.
Liverpool	20	10	0	Liverpool ...	14	5	0	Liverpool	21	10	0
Ibadan	13	0	0	Ilorin	6	15	0	Kano	12	0	0
	£7	10	0		£7	10	0		£9	10	0
Export duty and Produce Inspection fee	1	3	3	Freight Ilorin to Ibadan, 123 miles, Class 2.	1	0	6	Freight Kano-Ibadan, 585 miles, Class 3 ...	3	15	10
								Export duty		10	0
Margin	6	6	9		£6	9	6		£5	4	2

Comparing Ibadan prices it will be seen that the margin left for ocean and rail freights, bagging charges, etc., is not very different from that for palm-kernels, though higher than that for groundnuts, which at the present time offer little profit to the exporter.

It is considered that with a home price of £14 5s. per ton fair local prices for dry kernels would be :—

Ilorin. £6 10s. per ton or 3s. per bushel.

Minna. £5 8s. ,, ,, ,, 2s. 6d. per bushel.

Zaria. £4 10s. ,, ,, ,, 2s. 1d. per bushel.

with corresponding prices for outstations.

In the hope of encouraging the industry, the Nigerian Railway has already made reduction in freight charges by taking sheanuts out of Class 3 into Class 2. This difference has only been passed to the producer where competition has been keen. It has, however, tended to equalise prices throughout the different Provinces, as witnessed by the fact that towards the end of the season the prices at Badeggi and Zaria were the same, 2s. 3d. per bushel.

A further increase in price will only be possible when the home demand has been stimulated. Palm kernels are sold on an oil-content of forty-nine *per cent.*, and usually arrive in England with an F.F.A. of four *per cent.* If both seeds are to be applied to the manufacture of edible fats a difference of £6 5s. between the prices of the two appears unwarranted. The reasons for the low price prevailing on the home-market have already been discussed. They are :—

(i) The wide divergence in quality in different shipments.
(ii) The variation in exports from year to year.
(iii) The prejudice against the use of shea butter in edible fats.
(iv) The low price obtainable for acid fat.
(v) The low price obtainable for press-cake.

Analyses of shea " nuts " and shea cake are given in Table VIII. It will be seen that the carbohydrate content of shea cake is high, but it should find ready use in the manufacture of " compound " cake. The prevailing price for shea cake is not known. One firm of crushers reported that in 1926 they could obtain only £1 5s. per ton as against £3 15s. the previous year. Since palm kernel cake sells round about £8 per ton, this difference immediately brings the value of shea kernels £3 to £4 below that of palm kernels. As the consignments received by this firm in 1926 varied in F F.A. from 4.5 *per cent.* to 19.2 *per cent.*, acidity or even rancidity may have been the reason for the sudden fall in the price of press-cake.

TABLE VIII. (6).

Composition in parts per 100 of :—	Moisture.	Fat.	Albuminoids.	Digestible Carbohydrates.	Fibre.	Mineral Matter.	Sand.
Sheanuts. W. African	5·65	48·80	7·38	32·74	2·68	2·75	0·5
do. do. ...	5·80	52·67	9·38	26·15	3·25	2·75	—
Sheanut cake do. ...	12·70	4·73	12·37	57·67	6·48	6·05	0·65
Sheanut Meal	7·85	20·30	11·13	48·54	6·68	5·50	0·90
Sheanut cake Spanish	9·95	6·50	12·13	60·74	4·78	5·90	0·45

Serious attempts have recently been made to bring shea butter into greater favour with edible-fat manufacturers, and a special crushing mill has been erected at Liverpool with this object. A home price of £18 per ton would mean an almost doubled price to the native, and one cannot doubt that this would lead to a large increase in production in the present buying centres and to the extension of the industry to areas where, after deducting freight charges, the present price can offer no attraction.

IX.—UNSAPONIFIABLE MATTER AND OIL-CONTENT.

Table IX contains the results of analyses for oil-content and unsaponifiable matter, made in an attempt to account for the variation of these values in different commercial consignments. Determinations made on Nigerian kernels at the Imperial Institute (7), are included for the sake of comparison, and are marked with an asterisk.

Unless otherwise stated, the material analysed was fresh nuts, which had been boiled and sundried to preserve for analysis. All determinations of unsaponifiable matter were made by the Bolton-Revis method (8), using petroleum ether, b. pt. 40°-60°C. This method, which involves the extraction of the dried soap, mixed with sodium bicarbonate and sand in a Soxhlet, was preferred to the ordinary practice of extracting the aqueous soap solution, by reason of the large loss of solvent which is incurred when the latter method is used in the tropics.

The following factors were examined.

(*i*) *Varieties.*—

Fruits from round and long, spreading and upright types, also double-seeded fruits were examined.

(*ii*) *Age of Tree.*

Six full-sized fruits, not quite ripe, were plucked from five trees of each of the following sizes :—

	Girth 5' from ground.	*Height.*
(*a*) Old	Over 50 inches	45 feet and over.
(*b*) Middle-aged	25 to 45 inches	25 to 40 feet.
(*c*) Young ...	Under 25 inches	Under 25 feet.

A representative sample was also chosen from ripe fruits collected from :—

(*d*) Trees over thirty feet in height.
(*e*) Trees under twenty-five feet in height.

(*iii*) *Maturity of Fruit.*

Ripe fruits and full-sized hard fruits were collected from the same tree.

(*iv*) *Climatic Variation.*

Collection was made in areas of widely different climates. Fruits from the Zaria Province are compared with those from Jebba.

(*v*) *Germination.*

On germination a thin latex oozes from the kernel. It seemed likely that this loss would reduce the unsaponifiable content. It was not possible to follow the actual change on germination, but germinated fruits were collected to see whether the unsaponifiable content of the kernels were markedly different from that of ungerminated kernels from the same locality.

Table IX.

Oil-content and Unsaponifiable Matter.

Kernels.	Percentage oil on dry weight.	Percentage unsaponifiable matter in oil.
(i).—Types of Fruit.		
1. Iponrin round (1)	50·8	6·4
2. do. do. (2)	53·4	6·1
3. do. long	52·4	7·8
4. do. double...	51·7	7·5
5. do. mixed	53·1	5·9
6. Bode Sadu round	51·3	7·0
7. do. long	53·0	7·2
8. do. double	51·9	6·8
*9. do. range of 9 determinations ...	45·2 — 51·5	5·6 — 8·3
10. Bakeko spreading	47·8	9·2
11. do. upright	44·3	8·1
(ii).—Age of Tree.		
12. Iponrin(a) }	49·8	9·0
13. do. (b) } Unripe	50·6	8·9
14. do. (c) }	49·8	9·6
15. do. (d) } Ripe	54·5	7·4
16. do. (e) }	53·3	7·3
(iii).—Maturity of Fruit.		
17. Iponrin ripe	52·7	6·5
18. do. unripe	52·3	8·6
19. Bakeko ripe	49·5	8·4
20. do. unripe	49·3	10·3
(iv).—North *v.* South.		
21. Samuru (Zaria)	39·3	11·2
*22. do.	41·4	9·0
23. Zaria (Hausa prepared)	46·1	10·8
*24. Maigana (Zaria)	35·6	8·8
25. Shika (Zaria)	42·4	11·6
26. Jebba (Yoruba prepared)	51·4	4·4
27. do. do.	49·7	5·8
(v).—Germinated.		
28. Biri-Biri germinated	38·5	7·4
29. Bakeko do.	39·5	8·8
30. Samuru do.	36·3	10·2

The number of observations is too small to permit of any definite conclusions, but two points seem fairly certain.

(1) Unripe fruits contain more unsaponifiable matter than ripe fruits.

(2) Fruits from the extreme north contain less oil and more unsaponifiable matter than those from further south. This is also suggested by the analyses of Hausa butters (p. 98).

This phenomenon, together with the change in fruit size already cited, is probably connected with water supply.

Between trees of different age and type there appears no significant difference. Loss of unsaponifiable matter on germination appears to be approximately balanced by the loss of oil already noted.

PART II.

SHEA BUTTER.

Shea butter is used by the native of the Northern Provinces for roughly the same purposes for which the Southerner employs palm-oil. It is used in cooking, as an illuminant, and as a base for ointments and medicines. Its preparation is both tedious and involved, and calls for no little skill. As a result, in the neighbourhood of towns the manufacture is confined to a few villages which have specialised in its production and supply markets within a wide radius. They are jealous of the reputation of their butters and many Yoruba villages have a distinctive shape of " pat ".

Of the four methods of preparation, Nupe and Yoruba involve roasting, whilst the Hausa and Munshi methods deal with unroasted kernels The whole of the production is in the hands of women and children.

X.—YORUBA PROCESS.

The starting material is sundried kernels. The buttermaker usually waits until she has been able to buy and prepare six standard baskets, this being a convenient quantity to use.

1. *Roasting.*—A perforated earthenware pot, holding a basketful of kernels, is built into the top of a mud oven. Ovens vary greatly in size and shape, but the commonest form is about two feet high, long enough to take two to six pots in series. Each pot is provided with a separate firing hole into which a red-hot piece of wood is pushed and fanned into a small flame. When the pot is

heated up, the kernels are added, and as the pot sits close to the flame they are regularly stirred to prevent their burning. 150°C is a common temperature in the middle of the mass, and one lot which had not been stirred for five minutes had reached 185°C. The duration of roasting depends on the oven and on the moisture content of the kernels. Well-sunned kernels can be roasted in under an hour, but if, as often happens at the beginning of the season, it is necessary to use imperfectly dried ones, roasting may take over two hours.

The process is complete when the kernels shine with oil and are beginning to split. They should be dark brown, though it is difficult to avoid charring. The cross section is deep chocolate as against the purplish brown of sundried kernels.

2. *Pounding.*—Whilst hot the kernels are pounded as finely as possible in a mortar. The product is a sticky liquid containing small lumps of unbroken kernels.

A potful of roasted kernels weighs sixteen to seventeen lb. This quantity was pounded by four girls, beating in the same mortar, in twenty-five minutes.

3. *Grinding.*—A little of the pounded mass is placed on the upper end of a sloping smooth slab of stone and gradually worked down by a smaller stone with a rocking motion. Any lumps are broken down and the resulting smooth paste slides from the stone into a calabash in which a little waste water from the *Floating* process has been placed to prevent sticking. The paste is then allowed to stand overnight, when it hardens and may be crumbled between the fingers.

Sixteen lb. of pounded kernels were ground by two girls in one hour.

4. *Treading.*—About a pint of hot water is placed in a large earthenware pot sunk level with the ground. The paste is added, sprinkled with a little hot water, and allowed to stand for about twenty minutes. A girl then stands in the pot, and treads the mass until it becomes too sticky to work. A little more hot water is added, and treading and addition of water are continued until a silvery grey spongy dough is formed.

The paste from sixteen lb. of roasted kernels was trodden by one girl in half an hour.

5. *Floating and Washing.*—The product is then poured, a little at a time, into a large pot filled with cold water, in which it is thoroughly worked up by the fingers. A greyish scum of fat rises

to the surface. This is lifted out with the hands and washed in a second pot of water. It is then squeezed into a ball and patted to remove as much dirty water as possible.

The fat is a dirty grey, whilst the washing water has both the smell and appearance of cocoa, owing to the fine particles of fibre held in suspension. This liquid is thrown away.

One woman treated the fat from ninety-nine lb. of roasted kernels in half an hour.

6. *Refining.*—A large native pot is heated over a big fire, and the butter added in balls of about two lb. weight, each one being allowed to melt before the next is added. The fat is stirred and, after about an hour's heating, water begins to boil off. With continuous stirring, boiling is continued for two hours, during the last half hour of which only the upper layer is stirred. The process is usually started in the middle of the afternoon and the fire damped down at night. The pot is usually quite warm the following morning when the process is continued at daybreak.

A very thin scum is first removed from the surface; this is put into the maker's lamp. The upper layer of clear brown fat is then carefully ladled off into two large calabashes. A muddy black liquid remains at the bottom of the pot. This is agitated with a little boiling water and a further yield of fat rises. This is of a slightly darker colour than the first yield, and is either used for burning or introduced at operation 5 into the next batch of butter to be made.

After the second extraction there remains a sticky black mass whose only use is for filling up cracks in the house walls.

7. *Solidifying.*—The butter is agitated violently in two large calabashes by a piece of stick for an hour, after which time it begins to thicken. It is essential that this process be carried out in a cool corner of the compound before the sun has risen above the walls, otherwise setting takes much longer. When thick, the butter is spread round the edge of the calabash, left for about fifteen minutes, stirred and spread out again. After an hour's intermittent stirring the butter sets semi-solid.

8. *Moulding.*—Small earthenware cups are set in rope rings and on these the butter is shaped by the old woman of the village by adding small pieces at a time and smoothing out into a pat which may be flask-shaped or mitre-shaped, the particular design being characteristic of the village. The commonest size is a shape weighing about six lb., of which five can be made from six baskets of kernels, a little being left over. The moulder shows an uncanny

skill in judging weight, and of five shapes weighed, everyone was within an ounce of six pounds. The shape is wrapped about with leaves and sold in this form in the market. The butter is cream to greenish grey. Occasionally it has a dirty brown or grey colour which the natives believe to be caused by overroasting. This may be a contributory cause, but the actual impurity consists of very fine particles of fibre which can readily be removed by sedimentation or filtration. A very small quantity is sufficient to discolour the fat (c.f. Bode Sadu Grey, Table IX), and as it cannot be used for edible purposes it is usually sold for a penny a pound less than white butter. A similar case has been observed in the overboiling of palm oil, when the fine particles of dehydrated fibre take up oil and assume a volume entirely disproportionate to their weight.

Yield.

1.—Weights of Kernels and Butter.

Demonstration.	Wet Kernels.	Roasted Kernels.	W. Butter.
1. Iponrin 1 ...	6 baskets 158 lb	99 lb	32½ lb
2. do. 2 ...	6 do. 152 „	100 „	34 „
3. Odetunde ...	10 do. 300 „	181 „	60 „
*4. Kure ...	—	78 „	28 „

2.—Percentage Recovery of Oil.

Analyses made throughout the course of Iponrin 1 are :—

	Weight lb	Percentages of :			Total weights of :	
		Water.	Oil.	Unsaponifiable matter in oil.	Oil lb	Unsaponifiable matter lb
Wet Kernels	158	27·0	36·9	7·2	58·3	4·20
Roasted Kernels ...	99	0·01	42·5	6·6	42·1	2·78
1st Residue (fine chocolate powder) ...	—	on dry wt.	19·6	7·1	—	—
Black Residue	26	45·0	28·9	7·0	7·51	0·53
Butter	32·5	0·12	99·8	6·1	32·4	1·98

Recovery of oil (1) from wet kernels 55·6%
(2) from roasted kernels 77·0%

Loss of Oil.—The percentage recovery of oil from the roasted kernels must be considered very good, and but for the very large loss on roasting the process would be very efficient.

The loss was greater than usual in this demonstration as it had been necessary to mix wet and nearly dry kernels in order to obtain the requisite quantity, with the result that a number were charred through uneven roasting.

The remainder of the oil is almost entirely lost in the black waste.

Loss of Unsaponifiable Matter.—An amount slightly disproportionate to the loss of oil is lost in roasting (in this process the pots become quite sticky) and in the following stages. The result is a slight reduction in the unsaponifiable content of the butter.

Returns.—Two women, unaided, can convert six baskets of kernels into butter in five days. Iponrin (2) was made in this time. Iponrin (1) was made in two days by mass production, each basket being treated separately until the floating process. The times given in the description of the process are rough averages for one basket.

Determination No. 4. (Kure) was made by Mr. T. Thornton, late of this Department, in 1927. He gives the following figures:—

Kernels (78 lb.) value	6s. 6d.
Butter (28 lb.) value (4.18d. per lb.) ...	9s. 9d.
Profit	3s. 3d.
Woman hours of preparation	52
Value per woman hour	0s. ¾d.

The calculation does not include the labour necessary for fetching wood and water, which is a considerable item. Allowing for this, the labour involved in the preparation of Iponrin (1) was roughly seventy woman-hours. The local price of butter was 3d. per lb., most of it going to Ilorin market, twenty-three miles away, at 4d. per lb.

Value of kernels (158 lb.)	6s. 0d.
Value of butter (32.5 lb.)	8s. 1½d.
Profit	2s. 1½d.
Return per woman-hour	0.36d.

The prices quoted for Kure are high, since 1927 was a bad season. Odetunde (No. 3) represents the other extreme. Ten baskets of kernels costing five shillings had yielded sixty lb. of butter, which the makers hoped to sell at 1½d. per lb. in Bode Sadu market, thus making a profit of 2s. 6d. At the time the best quality of butter could be bought in Bode Sadu at 1d. per lb., at

which price the maker could make no profit. The difference was adjusted later in the season, partly by the action of middlemen in railing butter to places where higher prices were being offered (nine tons were railed south in petrol tins from June to September) and also by the native taking advantage of the bigger profit of 6d. a basket to be made by selling the kernels to the stores or middleman. Accordingly there was no response when in August the stores offered $2\frac{1}{4}$d. per lb. for butter.

XI.—NUPE PROCESS.

The general procedure is very similar to that in the Yoruba preparation.

1. *Roasting.*—After being shelled, the kiln-dried kernels are put back into the kiln, and heated for about six hours, with occasional turning over. The temperature reaches about 120°C. in the middle of the mass. Oil exudes from the kernels, and roasting is complete when they begin to split.

2. *Pounding* and 3. *Grinding.*—These processes, and the times taken, are exactly similar to those of the Yoruba method.

4. *Kneading.*—This operation replaces the Yoruba *Treading.* Without being allowed to harden, the ground paste is mixed in a large mortar to a thick paste, by the gradual addition of about an equal weight of cold water. The paste is then spread around the sides of the mortar, and allowed to stand for twenty to thirty minutes.

A little hot water is then added, and the mass vigorously kneaded with both hands. Addition of water and kneading are continued until the paste changes from chocolate to silver grey.

5. *Extraction.*—The mortar is filled nearly to the brim with cold water. By a circular one-handed motion the fat is drawn to the surface, placed in a calabash and rinsed once.

6. *Refining.*—The fat is added in small lumps to a heated pot. Water begins to boil off after about an hour, and boiling is continued for another hour, at the end of which time water is still being given off. Whilst still hot, the upper layer is ladled off into a large mortar. The first pot is kept boiling. As soon as the dirt in the mortar has settled, usually in about half an hour, the fat is carefully skimmed off into a large calabash. A muddy layer remains at the bottom of the mortar. This, together with the boiling residue from the

first pot, is transferred to a smaller pot, heated down further, and skimmed again. The second yield of butter, although considerably darker, is mixed with the first yield.

Yield Bakeko.	Weight.	Water. %	Oil. %	% Unsaponifiable matter in oil.	Oil Total weight.
1. Roasted kernels	99 lb.	1.32	40.6	7.6	40.2 lb.
2. Butter	35 lb.	0.23	99.7	6.9	34.9 lb.

Percentage Recovery of oil, from roasted kernels = 86.8%.

This is a better recovery than that obtained in Iponrin 1, but the percentage $\frac{\text{butter obtained}}{\text{weight of roasted kernels}}$ (35.4 *per cent.*) is almost the same as that found at Kure by Mr. Thornton (35.9 *per cent.*).

Loss of Oil and Unsaponifiable Matter.—In this demonstration roasting had been started before a sample of kiln-dried kernels could be taken. Samples of kernels from the same locality had an oil-content of over fifty *per cent.* on dry weight, and an unsaponifiable content round about eight *per cent.*, so that the loss of both oil and unsaponifiable matter appears very similar to that in the Yoruba process.

Returns.—Nupe butter was being sold locally, at the time of the demonstration, for 5d. per cash-bowl, or $2\frac{1}{2}$d. per lb.

Value of kernels (Owner's valuation)	5s. 0d.
,, ,, ,, ($2\frac{1}{3}$ bushels at 2s. per bushel) ...	4s. 8d.
Value of 35 lb. of butter	7s. $3\frac{1}{2}$d.
Profit	2s. $3\frac{1}{2}$d.

The labour put into the manufacture of this quantity of butter was practically the same as in Iponrin 1; the Yoruba process is longer only because it entails waiting overnight, (*a*) for the ground paste to stiffen, (*b*) for sedimentation in the refining process.

The return per woman-hour in the two processes is, therefore, almost identical.

The local market at Juafu is attended by middlewomen who resell in Bida market, where the price at the time was $3\frac{1}{2}$d. per lb. and rose to 4d. in September. The profit on reselling a kerosene tin of butter, after deducting 9d. for headloading fifteen miles, was two shillings and sixpence.

Middlemen were also making handsome profit by railing butter in sealed kerosene tins to Kaduna, Zaria and Kano, where butter was selling at 5d. to 7d. a lb.

The store price was below that offered in the native market. Starting at $2\frac{1}{8}$d. a lb. it was raised in August to $2\frac{3}{8}$d. in an attempt to combat the kerosene tin trade.

MODIFIED NUPE PROCESS.

The following method of extraction is used when a small quantity of butter only is required. It is employed by both Gwaris and Nupes.

(*a*) The kiln-dried nuts are pounded finely in a mortar, screened, and the larger pieces repounded until the whole mass has been reduced to a coarse flour, which is then allowed to dry out in the sun for a day.

(*b*) The flour is gently dried at about 110° by heating in a small pot, stirring continuously. Drying is complete when the flour has changed to dark chocolate.

(*c*) The roasted flour is pounded again and ground, the rest of the procedure following the large scale Nupe method.

XII.—HAUSA PROCESS.

(*a*) *Pounding.*—Sun-dried kernels are pounded in a mortar to a coarse flour which is repeatedly sifted and the larger pieces repounded. The flour is sunned for a day..

(*b*) *Soaking.*—The flour is soaked in roughly twice its weight of water and allowed to stand overnight.

(*c*) *Grinding.*—Next morning the soaked kernels are ground to a smooth paste on a sloping stone.

(*d*) *Extraction.*—The paste is taken to the river in a large calabash, water added in small quantities and thoroughly mixed by a circular one-handed motion.

When the paste begins to change colour a large excess of water is added and the fat floated to the surface by agitation. The fat rises as a mass of semi-solid curds, as distinct from the sticky liquid produced in the Yoruba and Nupe extractions. These are very thoroughly washed, then squeezed into a lump.

The waste water in this process is of a very light chocolate colour.

(*e*) *Refining.*—This operation is similar to the Nupe method.

Hausa butter is an attractive pale yellow. It is allowed to set in calabashes and sold in this shape. The production is so limited that Nupe butters, railed from Badeggi, can compete in the Hausa markets.

Yield.—No large-scale preparation of Hausa butter was seen, but a rough idea of the yield obtained can be formed from the following experiment, in which a small scale extraction was carried out against the modified Nupe process, using the same material.

Each extraction was carried out with eight lb. of dried flour obtained by pounding sundried kernels:—

	Weight lb.	% Water,	% Oil.	% Unsaponifiable matter in oil.	Total weight of oil lb.
Flour	8	7.61	42.6	10.8	3.41
Nupe:					
Roasted flour ...	7	4.02	37.9	10.4	2.65
Butter	1.06	0.10	99.8	8.6	1.06
Hausa:					
Butter	0.89	0.11	99.7	10.7	0.89

Both yields are necessarily low on account of the relatively large loss on the utensils in a small scale operation, but it appears that despite the loss of oil on roasting, the Nupe method gives the better yield. The point needs further investigation, as does the apparent fact that the Hausa causes practically no reduction in the unsaponifiable matter.

XIII.—MUNSHI PROCESS.

The following details of the Munshi process were supplied to the Department by Mr. W. G. Hughes, Benue Agent of Messrs. John Holt, in 1924.

(*a*) Fruits are gathered from the tree, stripped of their green covering and the kernels boiled in the shell for at least two hours.

It is essential that the fruits be boiled while absolutely green, *i.e.*, not more than forty-eight hours after being gathered from the tree. If allowed partially to dry before boiling, the butter is black and of little value.

(*b*) The kernels are peeled and soaked in water for at least two days.

(*c*) The soaked kernels are pounded to pulp in a mortar.

(*d*) The pulp is rolled vigorously on a flat stone by a round one.

(*e*) The wet mass is placed in a native pot until it is about a fifth full; the pot is then filled up with cold water. The mass is worked with the hands, when the oil rises to the surface and congeals. The fat is skimmed off and placed in a fresh dish, washing being continued until no more oil rises. The water in the cooler and the residue of the nuts are thrown away.

(*f*) The butter thus obtained is boiled for an hour, and is dirty brown in appearance.

Yield.—The usual yield is 1 lb. shea butter from 10 lb. of kernels.

The process is very similar to the Hausa, and the yield is of the same order if Mr. Hughes' figures apply to a small scale extraction.

XIV.—COMPOSITION OF NATIVE BUTTERS.

Analyses of native butters are appended in Table X.

Notes on Table X.

Colour of Molten Fat.—(Column 10). This is characteristic, and enables Yoruba, Nupe and Hausa butters readily to be distinguished. The colour is determined by the temperature to which the kernels have been heated.

The " Modified Nupe " butter falls half way in colour between Nupe and Hausa.

Saponification Value. (Column 4).—This is a measure of the amount of alkali required to convert a given weight of fat to soap. Its magnitude depends on the constitution of the acids which make up the fat, but it is also reduced by the presence of unsaponifiable matter. There exists in these analyses a rough relation between unsaponifiable matter and saponification value.

Iodine Value. (Column 11).—The Iodine Value of a fat is determined by its degree of unsaturation, *i.e.*, its capacity to unite with oxygen, say, to form an addition compound. " Oxidising " or " drying " oils such as linseed oil, have a high Iodine Value, which falls when the oil is boiled.

It was at first suspected that the higher Iodine Value of Hausa butters was due to their preparation from unroasted kernels. This is not the only cause. On heating Zaria butter No. 10 for two hours on an oil bath at 160°C the Iodine Value was depressed only from 67.7 to 68.2. Determinations of the Iodine Value of the unsaponifiable matter by the Wijs method gave results varying from 127 to 139, so that an increase in unsaponifiable matter will raise the iodine value. This relation holds approximately for the butters analysed.

Table X.

ANALYSES OF NIGERIAN BUTTERS.

	Preparation.	Source.	Appearance.	Colour of Molten Fat.	Water percentage.	Dirt percentage.	Sp. Gr. 100/15° C.	F. F. A. percentage. (oleic)	Unsaponifiable Matter % (Bolton-Revis).	Saponification Value.	Iodine Value. (Wijs).
1.	Yoruba ...	Iponrin (1) ...	Cream	Brown	0·12	0·08	0·8643	0·62	6·1	180·6	60·6
2.	„ ...	Iponrin (2) ...	Dirty cream	„	0·20	0·24	0·8641	0·93	6·7	179·9	61·3
3.	„ ...	Odetunde ...	Cream	„	0·32	0·09	0·8646	1·10	6·6	181·7	60·2
4.	„ ...	Bode Sadu (1) ...	Dirty white	„	0·13	0·13	0·8632	1·72	5·9	180·4	59·0
5.	„ ...	„ „ (2) ...	„ grey	„	0·25	0·39	0·8634	0·81	6·8	181·0	60·2
6.	Nupe	Bakeko	Cream	Amber	0·23	0·08	0·8640	0·50	6·9	179·2	62·3
7.	„	Juafu	„	„	0·15	0·10	0·8640	0·47	7·4	178·0	63·7
8.	Modified Nupe	Samaru	Yellow	Straw	0·10	0·12	0·8653	0·70	8·6	177·7	65·0
9.	Hausa ...	Samaru	Yellow	Lemon Yellow	0·11	0·23	0·8671	0·60	10·7	177·0	68·2
10.	„	Zaria	„	„	0·18	0·15	0·8668	0·59	9·2	177·7	68·7
11.	?	Nigeria (Imp. Inst. Report)			—	—	0·8635	2·95	5·3	184·5	56·3
12.	Usual range	for mechanically expressed fat (7)			—	—	—	2–10	5–11	178–190	57–67

"KEEPING" PROPERTIES.

The statement that native butters no not "keep" well is often encountered. This is probably true of adulterated butters, which may contain large amounts of water mixed with yam-flour or wood ashes to avoid detection, but it is certainly not true of the ordinary market butter.

Samples 2, 7, and 10, Table X, were all bought in the native market. A portion of each was dried and filtered, stored in bottles, and tested at the end of three months against the undried and unfiltered butter, also stored in bottles.

F.F.A. (oleic.)

		After Three Months.	
	Original.	1. Filtered dried.	2. Unfiltered undried.
Iponrin (2)	0.93%	1.11%	1.15%
Juafu	0.47%	0.55%	0.58%
Hausa	0.59%	0.74%	0.84%

A sample taken from half a cask of butter which had been stored at Jebba for a year was also examined. This specimen had an F.F.A. of 8.18 *per cent.* and showed no trace of rancidity.

SUMMARY.

1. It is shown that the slow development of the Nigerian shea trade during the last twenty years may be ascribed to the failure of Nigerian sheanuts to conform to manufacturers' requirements. Whilst it is demanded of oil seeds used for the manufacture of edible fats, to which purpose sheanut oil is applied, that they shall have a low free acidity and a high oil content, and be available for purchase in constant quantity, shipments of Nigerian sheanuts have been both irregular in quality and variable in amount.

2. Conditions affecting the harvest of shea fruits are considered. It is concluded that, owing to the time of year at which the tree flowers, the crop must necessarily vary from year to year and from place to place.

3. The composition and characteristics of different types of fruit are studied, and analyses made of the kernels. It is shown that fruits from the north are larger than those from the south of the shea area, and that they appear to contain a lower percentage of oil and a higher percentage of unsaponifiable matter.

4. The various native methods of drying kernels are described and the products examined. It is shown that both sun-drying and kiln-drying, if properly carried out, give a product which meets manufacturers' requirements; that the inclusion of germinated nuts

and the imperfect storage of sun-dried kernels are the chief causes of deterioration in quality.

5. Conditions of marketing are discussed. It is shown that the narrow margin between store and buttermakers' prices provides little incentive for the picking and preparation of kernels.

6. The preparation of shea butter by Yoruba, Nupe, Hausa and Munshi is described. The percentage recovery of fat from the kernels is shown to be low.

ACKNOWLEDGMENTS.

Free use has been made of correspondence in the Departmental files. In addition to acknowledgments already made, Messrs. Jurgens and Mr. J. Allen of Crosfield's Soapworks, have supplied the Department with valuable information as to commercial requirements, and notes on "*mani-mani*", prepared by Mr. H. W. Park of the Niger Company, have been very useful. A report on "The Shea Trade in Northern Nigeria" presented to the Under-Secretary of State for the Colonies by Captain H. O. Nyance in 1912, has been of the greatest assistance.

The writer wishes to express his indebtedness to the many representatives of trading firms and to the Political Officers of the Ilorin and Niger Provinces for their kind hospitality and assistance; to Messrs. J. R. Mackie, C. H. Wright, W. B. Dowson, A. G. Beattie, A. G. G. Hill, and R. B. Shorter, of this Department, for invaluable help and information, and finally to Mr. W. A. Watson, who kindly carried out a series of absorption experiments during the writer's absence from the laboratory.

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PRELIMINARY NOTES ON A PEST OF THE SHEA TREE IN NORTHERN NIGERIA

BY

F. D. GOLDING, M.A., F.E.S.

In 1928 the writer was informed by Mr. M. Greenwood that shea trees, *Butyrospermum parkii*, in the vicinity of Badeggi in the Niger Province were frequently defoliated by caterpillars. A study was commenced of the bionomics of the pest and of the effects of its depredations upon the host plant; although these investigatoins are still in their initial stages, it was thought advisable to publish the data obtained to date as a supplement to Mr. Greenwood's paper (1; 1929) in the present Bulletin.

The caterpillars have been found to be the larvæ of a Saturniid moth, *Cirina butyrospermi*, Vuillet, which has been reported by Zacher (2; 1921) as a pest of *B.parkii* in the Western Sudan.

LIFE HISTORY.

The female moths oviposit in June the eggs being laid in compact clusters which are securely attached to the host plant; there are several hundred greyish-white pyriform ova in each cluster. The eggs are about 1.75 mm. long and are remarkably hard.

During July and August the larvæ feed on the leaves of the shea tree and when full-fed descend to the ground to pupate; larvæ kept in a cage in the laboratory pupated between August 27th and 30th. On November 7th, 1928, more than sixty pupæ were found in the soil beneath two shea trees at depths varying from nine to eighteen inches below ground level. With the object of determining the time of emergence of the adults and the possible effect of variations in soil humidity, a cage experiment was commenced in which ten pupæ were kept in dry soil, forty in moist and ten in saturated soil.

The following table shows the time of emergence of adults.

TABLE No. 1.

Time of emergence. 1929.	Dry Soil.	Moist Soil.	Saturated Soil.
March 1st	—	1	—
March 8th	1	—	—
March 29th	—	—	1
June 7th to 13th ...	1	10	—
June 14th to 20th ...	2	13	3
June 21st to 27th ...	2	3	2
June 29th	—	1	—
Total	6	28	6

The remaining pupæ were found to be dead. It will be seen that the proportion of pupæ from which moths emerged were :—

Moist soil seventy *per cent.* Dry and Saturated soil sixty *per cent.* each. As might be expected soil humidity appears to have little effect upon the pupæ, for the pupal period is usually, about nine and a half months in duration and is coincident with the five driest months of the year and two of the wettest.

Mr. G. N. K. Turnbull, Superintendent of Agriculture at Badeggi, has informed the writer that he observed a large number of moths on the morning of June 14th, there having been a fall of 0.76 inches of rain on the preceding evening. None had been seen by Mr. Turnbull before the 14th and only a few were seen on subsequent days.

EFFECTS OF DEFOLIATION ON THE HOST PLANT.

Little information was available as to the effects of defoliation upon fruit production and Mr. Turnbull kindly undertook to investigate this point. Six trees known to have been defoliated in 1928 and six thought to have escaped defoliation were kept under observation, the average yield in lb. of fruit per tree obtained in 1929 was nine from the first group and 118 from the second. It seems highly probable that defoliation has a very marked effect upon fruit production in the following season; it is hoped to obtain more data on this point next year.

On November 3rd, 1928, the writer was able to find only one defoliated tree at Badeggi; many trees said to have been denuded of leaves in the preceding August were covered with leaves.

CONTROL.

Zacher (2; 1921) has reported that the eggs of *C. butyrospermi* are parasitised by *Anastatus vuilleti* Crawf. (Hymenoptera: family Eupelmidæ) and that the Pentatomid bug, *Afrius purpureus*, Westw., attacks the young caterpillars. Specimens of *A. purpureus* have been taken by the writer at Ibadan and Zaria, and an egg parasite, as yet unidentified, has been discovered.

In the Badeggi district full-fed caterpillars, which have descended from the trees in order to pupate, are collected by the natives and utilised as food; dried caterpillars can be obtained in the markets of many towns including Ibadan, which is not in the shea belt.

SUMMARY.

1. Observations have been commenced on the bionomics of *Cirina butyrospermi*, Vuillet, the caterpillars of which defoliate shea trees, and on the effects of defoliation upon the host plant.

2. The female moths oviposit in June, and in August the full-fed larvæ pupate in the soil beneath the trees. The adults usually emerge in mid-June, but three out of a total of forty emerged in March.

3. It is highly probable that defoliation seriously reduces fruit production in the following season.

4. An egg parasite has been found. The full-fed caterpillars are utilised as food by natives in many parts of the country.

ACKNOWLEDGMENTS.

In conclusion the writer wishes to acknowledge his indebtedness to Messrs. G. N. K. Turnbull and A. G. Beattie for their valuable help.

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CORRELATIONS BETWEEN THE SPECIFIC CONDUCTIVITIES OF SOIL EXTRACTS, NITRIC NITROGEN AND SOLUBLE CALCIUM.

BY

C. H. WRIGHT, M.A., F.I.C.

PLAN OF WORK.

Samples of soil were taken from plots 14, 17 and 18 of the Cover Crop Experiment on Moor Plantation, the Headquarters of the Agricultural Department, twice a week during March and April, 1928, and after that once a fortnight until 24th August, 1928. These plots are three of a series on which every year various cover crops are followed by early maize with the object of finding their effects on the succeeding maize crops. The cover crop on plot 14 is *Dolichos Lablab* planted in June and dug in on 1st December; on plot 17 it is *Dolichos Lablab* planted in June and dug in during February. On plot 18 the weeds are dug in every year on 1st December and on 1st January. In 1928 the maize was planted on 7th April and reaped on 9th August.

The yields of maize in pounds per acre of dry grain on these three plots since the experiment was started were as follows.—

Year.	*Plot 14.*	*Plot 17.*	*Plot 18.*
1924 ...	1,688	1,428	1,051
1925 ...	900	620	576
1926 ...	1,468	1,556	1,106
1927 ...	1,401	1,412	1,240
1928 ...	1,456	1,418	1,056

In each of these plots there are forty-two rows, six of which at the south end are neglected for purposes of yield. Portions of soil were taken every time from the 12th, 18th, 24th, 30th and 36th rows starting from the south end in each plot, and the five portions were mixed to form one sample. Samples of soil used for the determinations described below were prepared from the air-dry samples; after removing " stones " with a 3 mm. sieve the samples were ground till they passed a 1 mm. sieve.

METHODS.

The procedure adopted for the determination of the specific conductivities of one to five extracts at 0°C. was the same as that previously described (7 and 10). The method consists in adding to 10 gm. of air-dry soil 50 c.c. of " conductivity " water at 5 p.m. and shaking. After shaking again at 7 p.m. the soil suspension is allowed to stand till 9 a.m. the following morning when it is filtered through

a Swedish filter paper, and the specific conductivity of the filtered soil extract at 0°C. is determined in millionths of a mho (reciprocal ohm) with a Wheatstone bridge, dial resistance box and telephone with stethoscope receiver. Two Arrhenius cells were used, one for the soil extracts and the other for the " conductivity " water; the cell constants of these, which were 0.22 and 0.096, were determined at intervals with N/100 potassium chloride solution. The " conductivity " water was prepared in a Bousfield pan still (2).

Nitric nitrogen was determined by the phenoldisulphonic acid method (1), using clear colourless extracts prepared by Harper's method (6). Soil extracts for the determination of soluble calcium and potassium were prepared in the same way as those used for the determination of specific conductivities, but larger quantities were prepared; 100 gm. of air-dry soil were mixed with 500 cc. of distilled water at 5 p.m., and after shaking again at 7 p.m. the mixture was allowed to stand till 9 a.m. next morning when it was filtered through Swedish filter paper. Calcium was determined by concentrating a measured volume of the soil extract and precipitating the calcium

TABLE.

Date.	Rainfall during previous period (inches.)	Specific Conductivities of 1 to 5 soil extracts at 0°C., millionths of a mho.			Nitric Nitrogen, parts per million of air-dry soil.			Soluble Calcium, parts per million of air-dry soil.		
		Plot 14.	Plot 17.	Plot 18.	Plot 14.	Plot 17.	Plot 18.	Plot 14.	Plot 17.	Plot 18.
March 2nd	0·00	47	57	36	22·5	35	12·5	24	36	26
„ 6th	0·10	42	64	39						
„ 9th	0·00	47	60	37	25	35	15	28	31	27
„ 13th	0·00	45	64	39						
„ 16th	0·17	50	67	38	22·5	32·5	20	22	26	21
„ 20th	0·00	42	57	42						
„ 23rd	0·70	39	40	32	25	27·5	15	19	18	18
„ 27th	0·02	43	57	37						
„ 30th	0·30	52	63	42	50	65	35	34	46	37
April 3rd	0·34	54	64	40						
„ 6th	0·83	37	53	33	20	35	15	19	29	23
„ 10th	0·97	38	44	36						
„ 13th	0·00	53	62	45	45	45	22·5	34	38	28
„ 17th	0·30	66	63	44						
„ 20th	0·00	49	75	52	35	50	30	34	44	31
„ 24th	0·47	54	85	44						
„ 27th	1·14	29	39	46	4	10	17·5	15	19	28
May 1st	1·01	36	47	32						
„ 4th	0·51	31	38	34	12·5	17·5	15			
„ 18th	1·09	20	35	26	5	17·5	12·5			
June 1st	8·65	18	21	19	0·5	0·7	0·4			
„ 15th	1·90	18	25	23	0·5	1·5	0·4			
„ 29th	0.41	17	24	20	1	5	4			
July 13th	6·73	18	23	17	1·5	3	2			
„ 27th	0·30	27	28	18	10	12	3			
August 10th	0·31	29	39	20	14	25	4			
„ 24th	1·82	22	31	19	11	14	2			

as calcium oxalate. The precipitate after filtering and washing was dissolved in dilute sulphuric acid and the filtrate was titrated with N/100 potassium permanganate solution, which had been carefully standardised with separate weighed portions of ferrous ammonium sulphate, between 0.1 and 0.2 gm. in weight. Potassium was determined in the soil extracts by the volumetric cobaltinitrite method (8) after evaporating a measured volume of the soil extract to dryness and igniting to get rid of ammonia and organic matter.

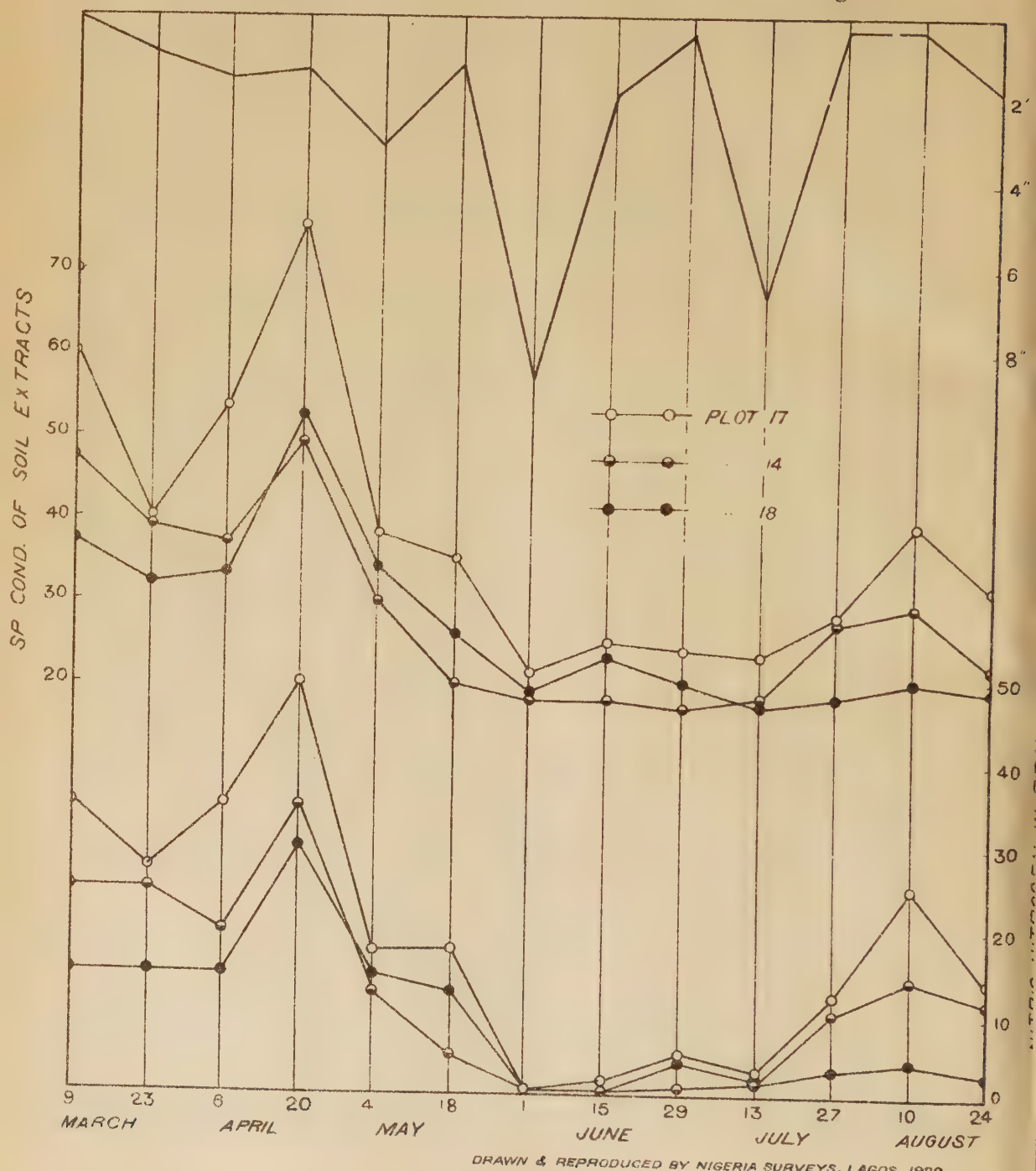
SPECIFIC CONDUCTIVITY AND NITRIC NITROGEN.

The results thus obtained, with the exception of the data for potassium, are given in the table, together with the rainfall during the period under review. The rainfall during each fortnight and the specific conductivities and nitric nitrogen contents of the three plots at fortnightly intervals are shown graphically in figure 1. It will be seen that the specific conductivities and parts per million of nitric nitrogen undergo similar changes on the three plots. Both these quantities increase during the dry weather until 20th April, after which there is a marked decrease in both quantities during the period of heavy rain and growth of the maize crop, which was planted on 7th April and reaped on 9th August. There is very little change between 1st June and 13th July, but both quantities increase between the latter date and 10th August, after which they both decrease. It will also be seen from figure 1 and from the table that on any particular day the specific conductivities of the three plots are generally in the same order of magnitude as the parts per million of nitric nitrogen. All the above facts show that there is a close relationship between these two quantities. The correlation coefficients between the specific conductivities and nitric nitrogen, calculated from the eighteen pairs of values for each plot in the table, are 0.905 for plot 14, 0.916 for plot 17 and 0.918 for plot 18. All these coefficients were found by the method given by Fisher (5) to be significant; the lowest (0.905) has a probability of more than 100 to one.

SPECIFIC CONDUCTIVITY AND SOLUBLE CALCIUM.

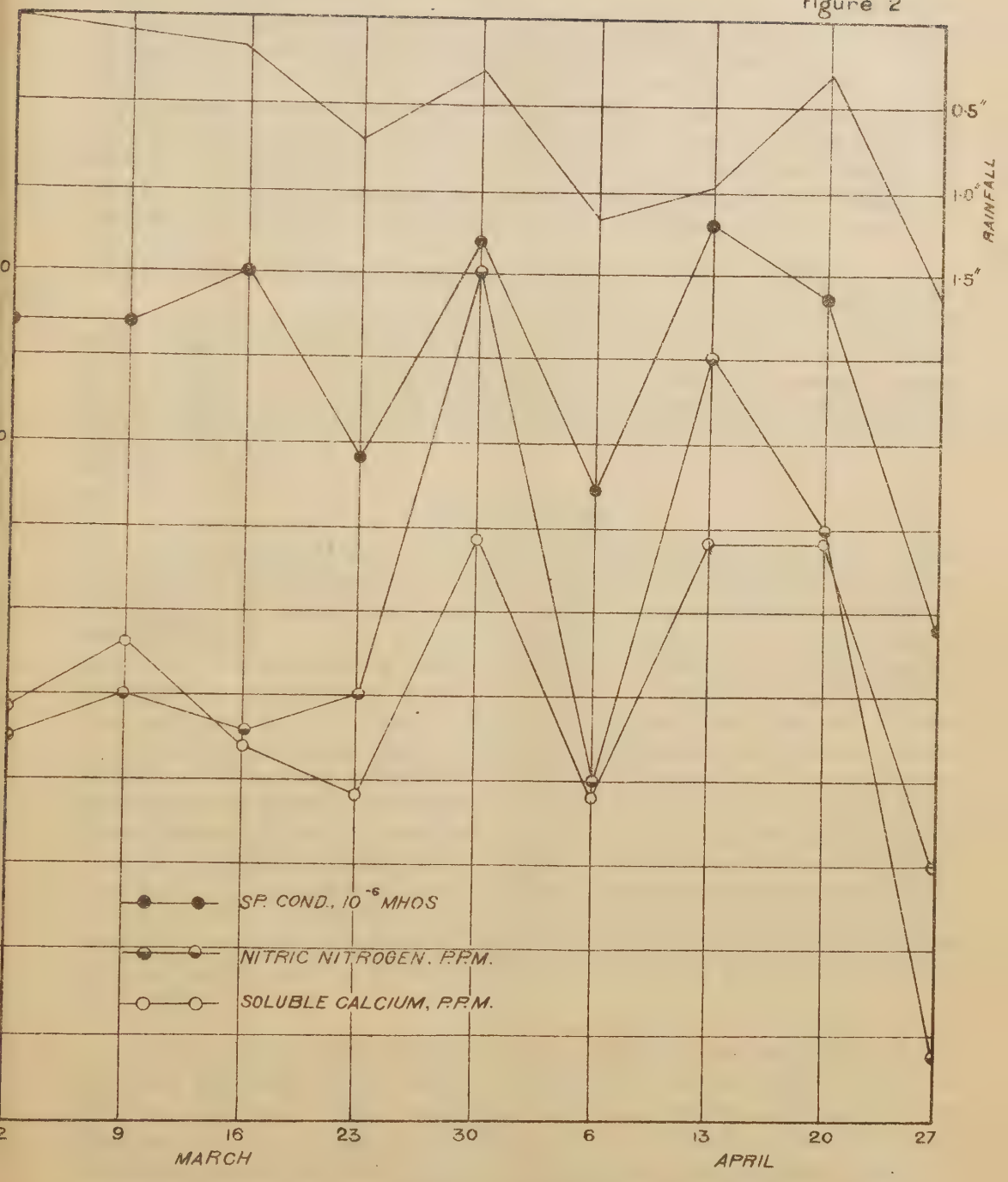
In figure 2 are plotted the rainfall each week and the data obtained for plot 14 at weekly intervals during March and April. This period includes the time at the end of the dry season when the specific conductivities and nitrates rose to their maximum values on the three plots. In the figure the specific conductivities and parts per million of nitric nitrogen and calcium are plotted on the same vertical scale. It will be seen that changes in the specific conductivities are accompanied by corresponding changes not only in the nitric nitrogen but also in the soluble calcium. Inspection of the

Figure 1



DRAWN & REPRODUCED BY NIGERIA SURVEYS, LAGOS, 1929

Figure 2



DRAWN & REPRODUCED BY NIGERIA SURVEYS, LAGOS, 1929.

figures in the table will show that during the same period the changes in the specific conductivities, nitric nitrogen and soluble calcium in the other two plots are similar, thus showing that there is a close relationship between these three quantities. The correlation coefficients between specific conductivities and soluble calcium calculated from the nine pairs of values for each plot are 0.858 for plot 14, 0.790 for plot 17 and 0.772 for plot 18. All these coefficients were found by the method given by Fisher (5) to be significant; the lowest (0.772) has a probability of more than fifty to one.

SPECIFIC CONDUCTIVITY AND SOLUBLE POTASSIUM.

There seemed to be some relationship between the specific conductivities and soluble potassium in parts per million determined in samples of soil taken from the three plots every week during March and April, but the correlation coefficients between these two quantities, calculated from nine pairs of values for each plot, were not significant.

DISCUSSION.

Burd, referring to the work on the composition of water extracts of soils done by himself and Stewart (3 and 9)*, states (4, page 412) that " we have observed in our studies of periodic water extractions that a rise in nitrate content of a given soil is invariably attended by a rise of basic constituents and notably calcium, pointing to a close relationship between biological activities and the solutes found. In water extractions, the non-nitrate mineral constituents thus become of increased importance as an index of biological activity." The specific conductivity is proportional to the total soluble matter in the soil extract, and data have been presented by the author (10) showing that the specific conductivity of a one to five soil extract is an index of the fertility of the soil. The correlations between specific conductivities, nitric nitrogen and soluble calcium given above now explain the reason why the specific conductivity is an index of fertility; they also show that a rise in specific conductivity is evidence of biological activity in the soil.

The author (10) determined the specific conductivities of soil extracts prepared from samples taken every twenty-eight days for one year (March, 1926 to March, 1927) from several plots on Moor Plantation and at Ilugun with the object of finding the extent of variation of the specific conductivities with rainfall and crop. It was thus found that there were considerable differences in the specific conductivities of different plots at any one time of the year and also

* The author regrets that at the time when this paper was written in Nigeria these two papers were not accessible.

differences on any one plot at different times of the year, the specific conductivities being highest in March (at the end of the dry season) and lowest in June and July (during the rainy season). At that time it seemed reasonable to explain the decrease in the specific conductivities as being the effects of leaching by rain and the removal of electrolytes by the growing crop, but it was not possible from the available data to offer any explanation of the increase in the specific conductivities. As a result of the further work described in this paper it is now possible to explain the increases in the specific conductivities previously observed as due to biological activities in the soil, which are accompanied by increases in the nitric nitrogen, soluble calcium and other basic constituents.

SUMMARY.

Samples of soil were taken at regular intervals from three plots under maize and the specific conductivities of the one to five soil extracts at 0°C. were determined. In the same soil samples nitric nitrogen and soluble calcium were determined in parts per million. It was found that the specific conductivity of the soil extract is correlated with the nitric nitrogen and the soluble calcium. These correlations, the coefficients of which are given, explain why the specific conductivity of a one to five soil extract is an index of the fertility of the soil; they also show that a rise in specific conductivity is evidence of biological activity in the soil.

ACKNOWLEDGMENTS.

The author wishes to acknowledge his indebtedness to his colleagues, Mr. O. B. Lean and Mr. C. B. Taylor, the former for kindly drawing the two figures in this paper and the latter for valuable assistance in calculating the correlation coefficients given above.

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FURTHER SURVEYS OF INSECT AND FUNGOID INCIDENCE ON IMPROVED ISHAN AND OTHER COTTONS IN NIGERIA.

BY

F. D. GOLDING, M.A., F.E.S.

In a previous paper (1; 1928) the writer gave an account of the incidence of pathogenic organisms on improved Ishan and other indigenous cottons at Ilorin in the 1927-28 season. The scope of the present paper is to describe the results of further investigations made at Ilorin, Ibadan and Badeggi (near Bida) in the succeeding season.

In each locality the main object of the experimental work was to compare the susceptibility to disease and the yield of improved Ishan (strain A.) and of the local cotton, both cottons being grown under conditions typical of the particular locality.

PLAN OF WORK.

In each locality two one-tenth acre plots were selected just after the cotton had been sown; each plot consisted of one-twentieth of an acre of Ishan A. and a similar area of the local cotton. These sub-plots were contiguous and of identical dimensions, each being twenty-two yards long and eleven yards wide.

In each locality an assistant was responsible for the collection of sheds and mummied bolls, for flower counting and harvesting. The writer visited the three localities in rotation with the object of assessing and diagnosing the damage to mummied and harvested bolls and of making general field observations. Lesions on bud and boll sheds at Ilorin were diagnosed by the writer and elsewhere by assistants, who had received special training prior to the commencement of the experiment.

Bud sheds were collected once a week, the plot having been denuded of sheds twenty-four hours previously. The number of sheds collected multiplied by seven gives a rough estimate of the extent of bud-shedding each week; it has been found impossible to obtain accurate figures by any practicable method (2; 1927).

Boll sheds were collected on six days a week and mummied bolls once a week. Flowers were counted at 11 a.m. on six days a week, the weekly total being calculated from the figures obtained in this manner. Flower counting was terminated on February 9th and all flowers produced on or before that date were marked.

Stainer (*dysdercus* spp.) infestation was estimated by the usual method, *vide* (2; 1927).

At Ilorin the groups of plots were on very variable soils and Mr. C. H. Wright kindly undertook a determination of the specific conductivities of soil extracts, the pH. values and the percentages of exchangeable calcium oxide for the various soils.

The monthly rainfall for the three localities is shown in Table No. XI at the end of this paper.

A.—INVESTIGATIONS AT ILORIN.

Ishan strain A. (*gossypium vitifolium*) was tested against Ilorin cotton (*G. peruvianum*), both species being interplanted with yams. Observations were also made on a one-twentieth acre plot of Kabba (probably *G.vitifolium*) grown through yams.

One group of Ishan and Ilorin cotton was sown on July 5th and the other on the 6th; Kabba was sown on July 16th. In all plots the ridges were six feet apart, the distance between cotton plants was two feet and between yam plants two and a half feet. Yams were harvested on November 17th.

Climatic conditions were very unfavourable after sowing, for only 0.24 inches of rain fell between July 14th and August 16th. By constant supplying Captain W. B. Dowson eventually obtained an excellent stand of cotton, *vide* Table No. I.

TABLE No. I.

Plot No. Variety of Cotton.	B. 29. Kabba.	B. 37. Ishan A.	B. 38. Ilorin.	B. 46. Ishan A.	B. 47. Ilorin.
No. of cotton plants per acre	3,240	3,480	3,480	3,320	3,400
%stand	92	99	99	94	97
No. of yam plants per acre	2,580	2,540	2,500	2,380	2,360
% stand	90	89	87	83	82.5

Rainfall.

The total rainfall for 1928 was 58.97 inches as compared with an average of 50.45 inches for the preceding twenty-three years, *vide* Table XI. As stated above, only 0.24 inches of rain fell between July 14th and August 16th, although the total for the two months was 14.11 inches or 3.64 inches above the average. The September precipitation was 3.29 inches below the average for that month.

INSECT INCIDENCE.

A.—Cotton Stainers.

The stainer index was carried out on cotton grown as a sole crop in Block G.; but, unfortunately, the infestation on this Block

was found to be atypical, only thirty-one adults being taken on Ilorin cotton and none on Ishan in the twelve weeks ending on December 20th. Stainer nymphs were numerous on late Bullrush Millet *pennisetum* sp.) in November and, in early December, recently-moulted migrant adults were observed on the survey plots in Block B. Stainers were fairly abundant up to March 23rd when the cotton was uprooted.

B.—Other Plant Bugs.

The writer has reported (1; 1928) that, in the 1927-28 season, various species of plant bugs were found attacking bolls from the end of December onwards. These insects were observed to be particularly numerous on improved Ishan intercropped with yams and they caused more damage than any other factor to ripe bolls of that cotton. A list of ten species of bugs was given of which four were doubtful pests as they had not been seen to be feeding on the bolls.

Fortunately in the present season plant bugs were scarce and it is hoped that their abundance in 1927-28 was abnormal as there is no record of their having been a pest of cotton at Ilorin before 1927.

Of the ten species mentioned above only one, *callidea natalensis*, st., was not found on cotton this year, but only one or two specimens of several other species were seen. *Halydicoris scoruba*, Dall., was again the most prevalent species on cotton and was found to breed on that crop; the young nymphs feed on buds and the life cycle is about five weeks in duration.

Frequent searches for plant bugs were made during October and November in fields of late Bullrush Millet and Guinea-corn, which were suspected to be alternative food plants. None was found before November 13th, but from the 21st of that month until the end of December, when the Bullrush Millet was ready for harvesting, plant bugs of the following species were common on the seed-heads, *H.scoruba*, Dall., *Nezara viridula*, L., *Agonscelis versicolor*, F., and *Mirperus torridus*, Wstw. (erroneously described as *Riptortus* sp. in 1; 1928). Nymphs of all these species, except *A.versicolor*, were discovered in early December and were placed in a wire gauze cage containing Bullrush Millet. All nymphs became adult before December 20th, when the Millet was almost ready for harvesting, and it is evident that a migration of adults from this crop to cotton occurs in late December. None of the plant bugs common on cotton in 1927 was found on guinea-corn.

Piezodorus pallescens, Germ., and a Coreid, *Acanthomia tomentosicollis*, st., were seen feeding on the bolls.

During the coming season the writer proposes to experiment with Bullrush Millet as a trap crop for cotton stainers and other plant bugs; it will be necessary to plant the trap crop on several different dates to ensure that there will be a supply of seed-heads throughout the cotton season.

C.—Bollworms.

Bollworm damage to harvested bolls was ten *per cent.* for Ishan, fourteen *per cent.* for Ilorin and twenty *per cent.* for Kabba as compared with 28.5 *per cent.*, twenty-nine *per cent.* and thirty *per cent.* respectively in previous season. The proportion of sheds and mummied bolls attacked by bollworms was also considerably smaller. *Diparopsis castanea*, Hmps. and *Earias insulana* Bois. were again the most prevalent species. *Argyroploce leucotreta*, Meyr. which was so abundant on tangerrines in 1927 and was controlled by burying attacked fruit, was scarce on both cotton and tangerrines.

D.—Empoasca facialis, Jac.

Jasid damage was first seen in the latter half of November about a month later than in 1927; the attack was not severe and few leaves were shed. Ishan A. was again Jassid-resistant.

E.—Helopeltis bergrothi, Reut.

This Capsid bug was more abundant than in the previous year and was particularly numerous on Kabba.

F.—Sylepta derogata, F.

No leaf rollers were observed.

Incidence of Fungoid and Virus Diseases.

(*a*) The virus disease, Leaf Curl, was almost entirely absent.

(*b*) *Bacterial Disease.*—Bacterial damage to sheds, mummied and harvested bolls was, generally speaking, even greater than in 1927, and this disease was the principal pest of cotton. Up to December 15th, seventy-two *per cent.* of the Ishan boll and flower sheds and fifty-nine *per cent.* of the Ilorin bore bacterial lesions; usually abscission occurred in the flower stage and there is no doubt that the Bacterial disease is a primary cause of shedding. This is of considerable importance at Ilorin for, as a general rule, the soil is poor and flower production is limited; therefore the yield is restricted *ab initio*.

It is impossible to assess the effect of bacterial infection in the form of Black-arm on the plant body, but it is obviously very considerable.

(*c*) *Alternaria* and *Diplodia* were extremely rare and anthracnose entirely absent.

(*d*) The physiological disease, Leaf Roll, due to excessive soil humidity (3; 1926), was common at the end of October, but the affected plants made a rapid recovery.

Bud Shedding.

The proportion of buds shed tobuds produced was from twelve to fifteen *per cent.* lower than in the preceding season, probably on account of the reduced bollworm infestation.

Flower Production.

In 1927 the writer found the flowering cycle of Ishan A. to be about three weeks later than that of Ilorin, in the present investigations there was a difference of about two weeks although the flowering zeniths of the two cottons were synchronous, viz., in the week ending on December the 8th. In 1927, the zenith of Ishan A. was attained in the corresponding week and of Ilorin in the week ending on November the 19th.

The shortage of rain early in the season checked growth and probably retarded flower production to some extent. In 1927-28 the secondary flowering cycle commenced in the week ending on January the 21st, whilst in the present season it began three weeks later with the result that very few bolls derived from flowers of this cycle were ripe when the cotton was uprooted on March 23rd. On the Ilorin plantation cotton is followed by groundnuts, which have to be sown after the first heavy rain in March, this means that cotton is often uprooted before its secondary cycle bolls mature, as was the case this year. Captain H. G. Poynter has suggested that groundnuts should be sown on the cotton ridges which would seem to solve the problem for the native farmer, though it will be necessary to impress upon him that his cotton should not be left longer than is absolutely essential.

Evidence is given below that flower production and, consequently, yield are limited at Ilorin by the poor quality of the majority of the soil.

Flower and Boll Shedding.—The proportion of bolls shed to flowers produced was lower for all varieties than in the previous

season by from seven to twelve *per cent.* Physiological shedding was again infrequent, and it is thought that the comparative scarcity of bollworms was the primary cause of this diminution.

The proportions of sheds attacked by bugs and bollworms were respectively 3.1 and 2.4 times greater on Ishan A. than on Ilorin the corresponding figures for 1927 were 3.0 and 1.7.

Mummied Bolls.—Five *per cent.* fewer bolls of both varieties became mummied than in 1927.

Harvested Bolls.—Analyses of damage to locks were made in the usual manner and the results are tabulated below in the form adopted in a previous paper (1; 1928).

TABLE II.

Period ending.	No. of bolls harvested per acre.	% undamaged.	% Damaged by			% unclassified.	Weight of Seed cotton.		% strained.
			Bollworms.	Bugs.	Bact.				
	ISHAN A.								
							lb.	oz.	
January 5th ...	870	30	16 [7]	5 [1]	46 [15]	3	3	4½	48
February 16th ...	33,950	63	8 [1]	14 [4]	12 [3]	3	160	10	13
March 23rd	13,910	71	17 [1]	7 [1]	5	0	73	12	14
Totals ...	48,730	65	10 [1]	12 [3]	11 [2]	2	237	10½	14
	ILORIN.								
January 5th ...	6,470	30	13 [8]	2 [1]	52 [12]	3	28	7	58
February 16th ...	43,050	47	13 [4]	17 [4]	20 [3]	3	207	3	36
March 23rd	13,600	59	19 [3]	11 [2]	9 [2]	2	66	9	28
Totals ...	63,120	48	14 [4]	14 [3]	21 [4]	3	302	3	36
	KABBA.								
January 5th ...	0	...	...	...	...	...	0	0	...
February 16th ...	11,800	37	23 [7]	16 [6]	22 [5]	2	45	15	32
March 23rd	22,720	55	19 [6]	13 [1]	11 [1]	2	103	12	35
Totals ...	34,520	49	20 [6]	14 [3]	15 [2]	2	149	11	34

The figures in brackets represent the percentage of locks rendered useless by the various factors ; these are included in the preceding total damage percentages.

A comparison of the figures in Table No. II with similar data obtained last year shows that there was a striking difference in the proportion of bolls maturing in the period ending January 5th; only two *per cent.* of the Ishan bolls and ten *per cent.* of the Ilorin ripened in that period in 1929 while the corresponding figures for 1928 were eleven *per cent.* and forty-one *per cent.* respectively. The retarded maturation this year appears to have been caused by three main factors, viz., the early drought which retarded growth, a greater degree of abscission of early bolls due to the prevalence of bacterial disease and, more doubtfully, augmented competition from the intercropped yams.

An outstanding difference between the Ilorin (*G. peruvianum*) yields in the two years is that, whereas in 1927-28 the proportion of the stained seed cotton increased as the season advanced, in the present experiment the reverse occurred. The unusual abundance of plant bugs in the latter part of the 1927-28 season was chiefly responsible for the increase in staining in the later harvesting periods; it is thought that the present season was more typical of the usual course of events.

Comparison of Ishan A. and Ilorin.

In both surveys Ishan A. produced a higher proportion of clean seed cotton and, although its yield has never exceeded that of Ilorin, the value of the Ishan crop was usually greater this year.

The average yields and the approximate value of the crop of the two cottons in the various variety tests carried out this year by the Superintendent in charge of the Ilorin farm are shown in Table No. III. The percentage of clean seed cotton is given, in brackets, after the yield.

TABLE III.

Block No.	Average yield, per acre of :— Ishan A.	Ilorin.	Approx. value of seed cotton :— Ishan A. £	s.	d.	Ilorin. £	s.	d.	Remarks.
B. 29-40	337 (92)	365 (83)	3	9	1	2	15	9	Grown with yams.
B. 41-57	143 (96)	194 (93)	1	9	6	1	10	0	,, ,, ,,
E. 29-44	199 (88)	202(81.5)	2	0	5	1	10	9	,, alone.
G. 80-100	140 (90)	148 (83)	1	8	7	1	2	8	,, alone.

Also it must be borne in mind that the ginning percentage of improved Ishan is about thirty-two as compared with twenty-six for the local cotton.

From Table No. V below it will be seen that although Ishan A. produced 8,560 more flowers per acre than Ilorin, there were 14,390 fewer Ishan bolls harvested than Ilorin. By abscission and mummification Ishan lost fifty-six *per cent.* of its bolls and Ilorin only thirty-seven *per cent.*; for comparison all available data on the degree of boll loss from Ishan are tabulated below.

TABLE IV.

Expt. No.	Locality.	Season	Variety.	% Loss.	Variety.	% Loss.	Remarks.
1	Ilorin ...	1926–27	Ishan (unselected)	59	Ilorin ...	41	Grown alone.
2	„ ...	1927–28	Ishan A ...	78·5	„ ...	68	„ „
3	„ ...	1927–28	„ ...	68	„ ...	54	With yams.
4	„ ...	1928–29	„ ...	56	„ ...	37	„ „
5	Badeggi ...	1928–29	„ ...	69	—	— .	Grown alone.
6	Adio (4 miles from Ibadan)	1925–26	Ishan (unselected)	56	Meko ...	49	„ „
7	Ibadan ...	1925–26	Ishan (unselected)	51	„ ...	42	„ „
8	„ ...	1928–29	Ishan A ...	43	„ ...	39·5	With yams.

Experiment No. 1 was carried out by Lean (4; 1927), Nos. 6 and 7 by Lean, Laycock and the writer (2; 1927) and the remaining experiments by the writer (1; 1928 and present paper).

Ilorin and Meko are both *peruvianum* and probably identical. It will be seen that Ishan lost a greater proportion of bolls than the local cotton in all experiments, and that the difference in degree of boll loss was, usually, considerably greater at Ilorin than at Ibadan. With the exception of experiments Nos. 6 and 8, in which bacterial infection was negligible on boll sheds of both varieties, a greater proportion of boll sheds of Ishan than of *peruvianum* have borne bacterial lesions. No *peruvianum* was grown in experiment No. 5. With the exception of experiment No. 8, in which bollworm damage was equal on both varieties, a greater proportion of boll sheds of Ishan than of *peruvianum* bore bollworm lesions and bug punctures. It is not possible to state definitely whether Ishan A. is preferable to the local cotton at Ilorin. In the coming season it is proposed to repeat the survey at Ilorin and to carry out two surveys at Bode Sadu (about thirty-four miles north-north-east of Ilorin), the centre of the cotton industry of the Ilorin Province; it is hoped that these investigations will yield conclusive results. The yield of Kabba, for the third year in succession, compared unfavourably with those of the other varieties, and, unless this cotton can be improved by selection, it will not be included in further surveys.

TABLE V.

		Ishan A.	Ilorin.	Kabba.
Buds.	Total No. per acre	140,910	131,370	80,280
	„ % Shed	22	23	33·5
	„ „ Attacked by Bollworms	2	3	3
	„ „ „ „ Bacteria	9	4	7·5
	„ „ Without lesions	11	15	22
	„ „ Unclassified	0	1	1
Flowers and Bolls.	Total No. Flowers per acre	109,480	100,920	53,400
	„ % Shed	46	26	26
	„ „ Attacked by Bollworms ...	12	5	11
	„ „ „ „ Bugs	12·5	4	5
	„ „ „ „ Bacteria ...	14	11	2
	„ „ Without lesions	4	4	4
	„ „ Unclassified	3·5	2	4
Mummied Bolls.	Total % Bolls mummied	10	11	9
	„ „ Attacked by Bollworms ...	1	2	5
	„ „ „ „ Bugs	3	2	1
	„ „ „ „ Bacteria	3	5	1
	„ „ Unclassified	3	2	2
Harvested Bolls.	Total No. Bolls harvested per acre ...	48,730	63,120	34,520
	„ % Locks undamaged	65	48	49
	„ „ „ damaged by Bollworms ...	10	14	20
	„ „ „ „ „ Bugs ...	12	14	14
	„ „ „ „ „ Bacteria ...	11	21	15
	„ „ „ unclassified	2	3	2
Yield per acre in lb. Seed Cotton		238	302	149
	% Seed Cotton stained	14	36	34

Observations on the Effect of Soil Quality.

As stated above the two groups of plots were on very variable soils. In 1926-27 season, Lean (4; 1927) encountered similar conditions in his investigations at Ilorin; one group of plots (B. 13 to 15) was on poor soil and the other (B. 34 to 36) was on good. Mr. C. H. Wright (6; 1928) determined the specific conductivities of the one to five soil extracts on December 2nd and 30th, 1926, and found the mean to be from thirteen to sixteen millionths of a mho. for the B. 13 to 15 group and from 18 to 24 for the B. 34 to 36 group. In the present experiment plots B. 46 and 47 were on poor soil containing numerous ironstone concretions while plots B. 37 and 38 were on better soil adjacent to the site of Lean's plot B. 36. Mr. Wright kindly undertook the examination of the soil in the four plots and furnished the writer with the data tabulated below.

TABLE VI.

Plot No. Variety of Cotton.	B. 37. Ishan A.	B. 38. Ilorin.	B. 46. Ishan A.	B. 47. Ilorin.
Specific conductivities of 1 to 5 soil extracts at 0° C., (millionths of a mho.)				
November 12th, 1928	18	21	12	12
December 10th, 1928	18	21	13	12
pH. Values	6·6	6.7	6·6	6.4
Exchangeable Calcium Oxide, *per cent.*	0·081	0·088	0·062	0·050

Mr. Wright has informed the writer that the specific conductivities of B. 46 and 47 are the lowest he has encountered in his soil work in Nigeria.

The survey results per acre for each plot are shown in the following table :—

TABLE VII.

Variety of Cotton. Plot No.	ISHAN A. B. 37.	 B. 46.	ILORIN. B. 38.	 B. 47.
Total No. Buds	203,220	78,600	191,540	71,200
„ % Shed	23	20·5	22	26·5
% attacked by Bollworms	3	1·5	3	2
„ Bacteria	7·5	11	4	4
„ Without lesions	12·5	8	14	20
Total No. Flowers and Bolls	156,460	62,500	149,680	52,160
„ % Shed	45	47·5	25·5	28·5
% attacked by Bollworms	13·5	7	5·5	3
„ Bugs	12·5	13	4	3
„ Bacteria	13	15	11	11·5
% Without lesions	2·5	9	3	7
Total % mummied Bolls	9	12	10·5	13
Total No. harvested Bolls	72,160	25,300	95,880	30,360
% Locks undamaged	64	67·5	50	41
„ damaged by Bollworms	10	12	12	21
„ „ Bugs	14	7	16	8
„ „ Bacteria	11	11	20	23
Yield per acre in lb. Seed Cotton	360	115	475	128
% Seed Cotton Stained	14	11	37	31
Yield per acre in lb. of Yams	15,792	8,540	15,008	8,200

Lean (4; 1927) found that, where the specific conductivity was high, (*a*) a higher percentage of buds and bolls were shed, (*b*) a greater number of flowers were produced, (*c*) flowering and bolling were delayed so that the final yield was higher and the percentage of clean cotton was greater, and (*d*) while cotton stainers were more active, there was less damage due to bollworms and bacterial disease.

In the present investigation, shedding and mummification were, with one exception, higher when the specific conductivity was low; flowering and bolling were not delayed and although the yield was greater where the specific conductivity was high there was a greater degree of staining.

Confirmatory results were obtained on the following points: where the specific conductivity is high, more flowers are produced and a greater yield obtained; cotton stainers are more active, but there is less damage, as a rule, due to bacterial disease and bollworms (on harvested bolls).

Generally speaking, physiological shedding was lower where the specific conductivity was high and there were fewer unclassified mummied bolls. It seems possible that mummied bolls without discernible lesions result from adverse soil conditions. The effect of poor soil on the growth of the cotton was very marked, and it was decided to measure the height of the main axes of forty plants in each plot. The plants were measured on November 27th, 1928, and again on March 3rd, 1929; the average stem heights in centimetres are recorded in Table No. VIII.

TABLE VIII.

Variety of Cotton. Plot No.	Ishan. B. 37.	Ishan. B. 46.	Ilorin. B. 38.	Ilorin. B. 47.
Average height on—				
27th November, 1928 ...	88	52	107	70
3rd March, 1929 ...	95	55	118.5	77

It will be seen that the Ishan plants on fair soil were 36 and 40 cm. higher than those on poor soil and that the corresponding figures for the Ilorin were 37 and 41.5 cm. on the two dates. The specific difference in height was also remarkably constant for the two groups of plots, Ilorin was 19 and 18 cm. higher than Ishan on November 27th and 23.5 and 22 cm. higher on March 3rd.

The yields shown in Table No. VII make it clear that the poor quality of the soil in two of the four surveys plots was the principal factor inhibiting yield. Much of the soil on the Government farm and in the vicinity of Ilorin contains a high percentage of ironstone concretions and is of poor quality. The writer is of the opinion that satisfactory yields of cotton will only be obtained on a few particular plots at Ilorin, and that cotton variety tests should, after next season, be confined to the principal cotton-growing area of the Ilorin Province, viz., Bode Sadu.

B.—INVESTIGATIONS AT BADEGGI.

Ishan A. was tested against Allen cotton (*G. hirsutum*) at Badeggi, about thirteen miles east of Bida in the Niger Province. American cotton was introduced into this Province some years ago and very little native cotton is now grown there; it was thought that improved Ishan might be more suited than the exotic cotton to this part of the country.

Both varieties were grown as sole crops as intercropping with yams is not customary in the Niger Province. The farmers in the vicinity of Badeggi grow little or no cotton and, when they heard that land was being prepared for cotton on the new Government farm, expressed the opinion that very small yields would be obtained.

Mr. A. G. Beattie, Superintendent of Agriculture, experienced great difficulty in acquiring the ten acres of land required and the cultivation before sowing was necessarily hurried. The land had been out of cultivation for many years. The Ishan was sown on July 6th and the Allen on the following day on ridges six feet apart; the distance between plants was eighteen inches for Ishan and twelve inches for Allen. A stand of 4,610 Ishan plants per acre and 6,740 Allen plants per acre was eventually obtained, *i.e.*, almost 100 *per cent.* stand of Ishan and ninety-nine *per cent.* of Allen.

Rainfall.—Unfortunately no rainfall records have been taken at Badeggi in the past and the writer had to utilise Bida records, kindly supplied by Mr. C. R. Butler, Superintendent of Education at that station. The total rainfall at Bida in 1928 was 49.72 inches compared with an average annual figure of 59.05 inches (1917 to 1927). The monthly distribution conformed fairly closely to the average figures except in September when 10.25 inches fell as compared with an average of 13.97 inches. No rain fell during November, December and January.

Insect Incidence.

(*a*) *Cotton Stainer*.—The stainer index was in operation from September 13th, 1928, to January 24th, 1929; in that period 1,002 adults were collected from $\frac{1}{8}$ acre of Allen and ninety adults from a similar area of Ishan. More than ninety-nine *per cent.* of the stainers were taken before the 29th of November. At the more northerly stations of the Agricultural Department, viz., Kano and Zaria, stainers disappear from the cotton in October on account of atmospheric aridity, and it is evident that Badeggi is climatically intermediate between these stations and those south of the Niger, where stainers may usually be found throughout the season.

The preference of *dysdercus* for Allen cotton is again exemplified; further evidence of this is contained in Table No. IX below.

(*b*) *Other Rhynchota*.—Plant bugs were unimportant, *agonscelis versicolor*, F. being the commonest.

(*c*) *Bollworms*.—As at Ilorin, *diparopsis castanea* and *earias insulana* were the most prevalent species, the former was more important on the early-maturing Allen while the latter damaged Ishan later in the season. Bollworm damage to ripe bolls of both varieties was considerable.

(*d*) Jassids were numerous on both varieties in early November and caused much reddening of leaves, but by mid-December these insects were scarce. Ishan suffered more than Allen; it is curious that this cotton is Jassid-resistant at Ilorin.

Incidence of Virus and Fungoid Diseases.

(*a*) *Bacterial Disease*.—Angular leaf spot was abundant in early November especially on Ishan, but was rare in mid-December; at that time many plants showed signs of severe black-arm.

Bacterial lesions were encountered more frequently than those of any other factor on boll sheds of both varieties.

(*b*) Leaf Curl, *alternaria*, and *diplodia* were extremely rare and no anthracnose was seen.

Monkeys were very troublesome early in the season, destroying about 200 Allen flowers and bolls.

Many of the plants of both varieties were stunted; on December 27th, the average heights of the main axes were found to be—Ishan 74.5 cm., Allen 65 cm. By January 7th, five *per cent.* of the Ishan and eleven *per cent.* of the Allen plants were dead; about half of the dead plants of each variety showed no signs of insect attack.

Bud Shedding.—The percentage of buds shed to buds produced for Ishan was 36.5 and for Allen 20.5; sixty-nine *per cent.* of the Ishan sheds and sixty-two *per cent.* of the Allen were without lesions.

Flower Production.—The primary flowering cycle of Allen reached its zenith in the week ending October 6th,—five weeks before the Ishan—and a small secondary cycle attained its maximum in the week ending January 12th. There was no Ishan secondary cycle before February 9th, when flower counting was terminated.

There were 158,990 flowers per acre in the primary Allen cycle of which thirty *per cent.* escaped abscission and mummification and produced 253 lb. of seed cotton; the corresponding figures for the secondary cycle were 30,020 flowers, twenty-seven *per cent.*, and 26 lb. of seed cotton. About nine *per cent.* of the total yield was obtained from bolls derived from secondary cycle flowers; it is evidently desirable to uproot Allen cotton in March rather than in mid-January when all first-cycle bolls have become mature.

Flower and Boll Shedding.—Allen shedding was normal, about sixty-six *per cent.* (2; 1927); the proportion of Ishan bolls shed to flowers produced, viz., 64.5 *per cent.* was the highest yet recorded for that variety. Forty-three *per cent.* of the Ishan boll sheds were without lesions and it is probable that many of the seventeen *per cent.* unclassified sheds were also of physiological origin; the cotton was grown in a light sandy soil and it is evident that the abnormally high shedding of Ishan was due, in the main, to soil dessication. (5; 1924). Bacterial lesions occurred on twenty-seven *per cent.* of the Ishan sheds.

Harvested Bolls.—From Table No. IX below it will be seen that, bug and bacterial damage to locks were both greater on Allen than on Ishan. The greater degree of bacterial infection was presumably due to the fact that the exotic cotton produced seventy-six *per cent.* of its flowers before the cessation of precipitation, *i.e.*, in the period of bacterial activity. The Ishan produced only twenty-four *per cent.* of its flowers in this period.

TABLE IX.

		Ishan A.	Allen.
Buds.	Total No. per acre	179,210	237,520
	„ percentage Shed	36·5	20·5
	„ „ Attacked by Bollworms ...	2	3
	„ „ „ „ Bacteria ...	6·5	2·5
	„ „ Without lesions	25	13
	„ „ Unclassified	3	2
Flowers and Bolls.	Total No. Flowers per acre	114,040	189,010
	„ percentage Shed	64·5	66
	„ „ Attacked by Bollworms ...	5	9
	„ „ „ „ Bugs ...	3	12·5
	„ „ „ „ Bacteria ...	18	13
	„ „ Without lesions	27·5	22
	„ „ Unclassified	11	8·5
	„ „ Attacked by monkeys ...	0	1
	Total *per cent.* Bolls mummied	4·5	4
Harvested Bolls.	Total No. Bolls harvested per acre ...	35,320	56,390
	„ percentage Locks undamaged ...	68	40
	„ „ „ damaged by Bollworms	20	23·5
	„ „ „ „ „ Bugs ...	5	20
	„ „ „ „ „ Bacteria ...	3	14
	„ „ „ Unclassified ...	4	2
	Yield per acre in lb. Seed Cotton	107·5	279
	Per cent. Seed Cotton stained	12	20

In the main variety test the average yields of seed cotton per acre were Allen 160 lb. and Ishan 63½ lb. The Allen gave definitely better results than the Ishan A. which appeared to suffer from soil dessication and was less resistant to Jassids. It should be mentioned that an even larger crop of Allen might have been obtained had the ridges been at a distance of 3½ instead of six feet.

Excellent crops of Allen cotton were seen in the Wuya district about thirty miles west of Badeggi.

C.—INVESIGATIONS AT IBADAN.

Ishan A. was tested against Meko (*G.peruvianum*), both being intercropped with yams. Both species were sown on July 9th, on ridges six feet apart; the distance between cotton plants was two feet and between yam plants twenty inches. Yams were harvested on November the 14th.

Unfortunately the experiment was somewhat vitiated from the commencement by the very poor stand of yams obtained, viz., forty-six *per cent.* in the Ishan plots and twenty-nine *per cent.* in the Meko. The stands of cotton were also unsatisfactory, 2,540 plants (seventy-two *per cent.*) for Ishan and 2,830 plants (eighty *per cent.*) for Meko; It will be seen that the Ishan cotton suffered from two initial disadvantages, viz.; a smaller number of plants and greater competition from the yam crop.

Rainfall.—The annual rainfall was 45.11 inches as compared with an average of 49.72 inches for the preceding eighteen years; the principal deviations from the monthly mean occurred in May and June, there being an excess of 4.08 inches in May and a deficit of 5.23 inches in June.

Between July 12th and August 16th, only 0.64 inches of rain fell.

Insect Incidence.

(*a*) *Cotton stainers.*—Stainer index picking from September 20th, 1928, to January 24th, 1929, gave the following results:—804 adults from $\frac{1}{8}$ acre of Ishan and 983 adults from a similar area of Meko, in the nineteen weeks. As many as seventy-one *per cent.* of the Ishan boll sheds and sixty-six *per cent.* of the Meko bore stainer punctures, while twenty-six *per cent.* of the Ishan locks and twenty-three *per cent.* of the Meko were damaged by these insects. Several plots of American cotton from Iraq were grown which proved very attractive to both stainers and bollworms; it is possible that these plots acted as foci for these pests.

(*b*) *Bollworms.*—Bollworm damage to locks was severe, viz., thirty-one *per cent.* for Ishan and thirty-six *per cent.* for Meko.

(*c*) Slight Jassid damage was observed on the two Meko plots in mid-November. No other insect pests were of importance.

Incidence of Fungoid and Virus Diseases.

(*a*) Leaf Curl was very rare.

(*b*) *Bacterial Disease.*—Angular Leaf Spot was slight on one Meko plot and unimportant on the remaining three plots. Only two *per cent.* of the Ishan boll sheds and three *per cent.* of the Meko bore bacterial lesions.

(c) *Alternaria and Diplodia* were rare; three *per cent.* of the Meko locks were affected by anthracnose.

Flower Production.

A check in the flowering of both cottons occurred in November with the result that the zeniths were not attained until the week ending December 15th, *i.e.*, one week later than at Ilorin although the competition from the yam crop must have been considerably less. The severe bollworm damage to locks was probably largely due to this flowering check for many bolls ripened very late in the season when bollworm activity was high.

Harvested Bolls and Boll Shedding.

Flower production, shedding, lock analysis and yield are shown in Table No. X.

TABLE X.

		Ishan A.	Meko.
Flowers and Bolls.	Total No. Flowers per acre	169,750	150,850
	„ % Shed	40	36
	„ „ Attacked by Bollworms	6	6
	„ „ „ „ Bugs	28	24
	„ „ „ „ Bacteria	1	1
	„ „ Without lesions...	3	3
Total ...	% Bolls mummied...	3	3·5
Harvested Bolls.	Total No. Bolls harvested per acre	97,390	91,060
	„ % Locks undamaged	30	19
	„ „ „ damaged by Bollworms ...	31	36
	„ „ „ „ „ Bugs	26	23
	„ „ „ „ „ Bacteria	9	11
	„ „ „ „ „ Anthracnose ...	0	3
	„ „ Unclassified	4	8
Yield per acre in lb. Seed Cotton		413	321
Percentage Seed Cotton stained...		26	42

The yields of the $\frac{1}{4}$ acre plots containing the survey plots, determined by the Superintendent in charge of the Ibadan plantation, were Ishan 280 lb. per acre and Meko 214; the ratio of the two yields was the same as that obtained by the writer, while the percentage of seed cotton stained, viz., twenty-four and forty-six, agreed closely with the figures shown in Table No. X.

The value of the crop per acre (based on the large scale experiment) was as follows:—Ishan A. £2 15s. 6d., Meko £1·11s. 5d. Ishan A. gave definitely better results than Meko in spite of there being fewer Ishan plants per plot and greater competition from yams.

TABLE XI.

SHOWING RAINFALL IN INCHES.

LOCALITY.	ILORIN.			BIDA.			IBADAN.		
Year.	1928.	1929.	Average 1905–27.	1928.	1929.	Average 1917–27.	1928.	1929.	Average 1910–27.
January ...	1·62	0·89	0·12	0·03	0	0	0·54	0·72	0·36
February ...	0	0·56	0·81	0	2·97	0·03	0	1·26	0·78
March ...	5·99	4·65	1·77	1·52	0·62	0·91	1·50	1·90	3·52
April	3·92	—	4·63	1·17	—	3·57	5·71	—	5·93
May	12·48	—	6·72	7·66	—	8·03	10·03	—	5·95
June	4·92	—	7·32	7·02	—	8·29	2·25	—	7·48
July	6·23	—	5·79	9·05	—	10·26	6·83	—	6·47
August ...	7·88	—	4·68	9·41	—	8·92	2·56	—	3·43
September ...	6·99	—	10·28	10·25	—	13·97	6·83	—	7·23
October ...	7·36	—	6·52	3·61	—	4·49	6·94	—	6·44
November ...	1·58	—	1·42	0	—	0·58	1·08	—	1·99
December ...	0	—	0·38	0	...	0	0·84	—	0·14
Total ...	58·97	—	50·45	49·72	—	59·05	45·11	—	49·72

SUMMARY AND CONCLUSIONS.

1. Surveys have been made of the factors affecting the development of improved Ishan A. Ilorin and Kabba cotton grown through yams at Ilorin; of Ishan A. and Allen grown as sole crops at Badeggi (near Bida); and of Ishan A. and Meko grown through yams at Ibadan. In each locality the main object of the experimental work was to compare the susceptibility to disease and the yield of Ishan A. and of the local cotton under conditions typical of that particular locality.

2. *Ilorin.*—(*a*) Cotton stainers were more numerous and bacterial disease more prevalent than in the 1927-28 season; but bollworms and jassids were less abundant. The plant bugs, which did so much damage to Ishan cotton last year, were scarce, and it is hoped that their abundance in 1927-1928 was abnormal. The virus disease, Leaf Curl was rarely seen.

(*b*) Ishan A. produced a higher proportion of clean seed cotton than Ilorin and, although its yield was less, the value of its crop was greater.

The principal cause of the lower yield obtained from Ishan A was a greater susceptibility to boll shedding. The yield of Kabba compared unfavourably with those of the other varieties for the third year in succession.

(*d*) One plot of Ishan and one of Ilorin were grown on soil with a very low specific conductivity and one plot of each variety was grown on soil with a higher specific conductivity. When the specific conductivity was low fewer flowers were produced and a lower yield was obtained; cotton stainers were less active, but there was, usually, more damage to ripe bolls from bollworms and bacterial disease. These results are similar to those obtained by Lean (4; 1927) in 1926. Contradictory results were obtained on the following points:—When the specific conductivity was low shedding and mummification were, with one exception, higher; flowering and bolling were not delayed and a smaller proportion of the crop was stained.

(*e*) The principal factor inhibiting yield at Ilorin appears to be the poor quality of the soil. It is thought that good yields will only be obtained on a few particular plots. Much of the soil is poor in the vicinity of Ilorin and it is suggested that, after next season, cotton variety tests should be confined to the principal cotton-growing area of the Ilorin Province, viz., Bode Sadu.

3. *Badeggi.*—(*a*) Cotton stainers were about eleven times more numerous on Allen than on Ishan; there was little difference in the bollworm infestation on the two varieties.

(*b*) The boll shedding of Allen was normal, but that of Ishan was excessive for an indigenous cotton and is thought to have been due chiefly to soil dessication and the prevalence of bacterial disease.

(*c*) The growth of the Ishan plants was poor and they gave a yield only two-fifths as great as that of Allen. Allen cotton appears to be more suited to the conditions appertaining in the Badeggi district.

4. *Ibadan.*—(*a*) Cotton stainers were numerous, possibly on account of the proximity of some exotic cotton, and bollworms did much damage to ripe bolls late in the season. There was little difference in the susceptibility of Ishan and Meko cottons to these insect pests and to bacterial disease.

(*b*) There were fewer Ishan plants per acre than Meko and, owing to variations in yam germination, Ishan encountered greater competition from the intercropped yams; in spite of these disadvantages Ishan gave a higher yield than Meko. The Ishan crop contained less stained seed cotton and was worth $1\frac{3}{4}$ times as much as the Meko crop.

ACKNOWLEDGMENTS.

In conclusion the writer wishes to record his indebtedness to Mr. C. H. Wright for making a chemical examination of the soil at Ilorin and for placing his results at the writer's disposal, and to the following Superintendents of Agriculture for their valuable help :—

Messrs. H. G. Poynter, W. B. Dowson, and F. E. Buckley at Ilorin; Mr. A. G. Beattie at Badeggi; and Messrs. D. H. Brown and R. M. Davies at Ibadan.

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COMPARATIVE OBSERVATIONS ON THE PESTS OF COTTON IN THE BENUE PROVINCE OF NIGERIA.

BY

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In the present paper an account is given of the first survey of factors affecting the growth of cotton at the experimental station of the Agricultural Department at Yandev, in the centre of Munshi country, between Abinsi and Katsina Ala.

Since cotton was first grown on the plantation in 1925, three varieties have been tested—Allen, the indigenous Munshi and the improved Ishan A. Because the Munshi grows most of his cotton through yams and as a result of field trials it has already been decided that Allen cotton is unsuited to this part of the country and the survey was planned to compare the two closely related varieties, the unselected Munshi and the improved Ishan A, when grown through yams.

A small amount of American cotton is grown by the Munshi. There are frequently a few odd plants growing on the outskirts of the villages, which probably originated from seed that was distributed in 1910 and in some subsequent years

Methods Employed.

The main survey was carried out in the C. 6 block where cultivation on ridges and heaps was being compared. Two-tenth acre plots of the two varieties grown on ridges were selected in two different parts of the block at the time the cotton was sown. The yams were sown on February 20th and the cotton on July 2nd by the Ball's single seed sand method. The single stands were two feet apart on one side of six foot ridges.

Bud sheds and mummied bolls were collected once per week, flowers were counted six days per week and bolls harvested once per week. Bud shed collection was discontinued after January 23rd, flowers were not counted after February 16th and the subsequent histories of only those bolls produced by this date were followed.

The only plots available for the stainer gauge on cotton grown alone was a variety trial of Ishan A., Munshi and Allen. The Allen was sown on July 16th and the Munshi and Ishan on July 3rd and 4th respectively.

The numbers of plants affected by Leaf Roll and Leaf Curl were estimated on other plots.

All figures except those of the stainer gauge are given per acre.

Germination.

The greatest difficulty was found in securing a good stand of cotton through yams and there is little doubt that during the past season drought was the greatest factor preventing heavy yields.

The monthly rainfall figures (*see* table No. 1) do not show the drought clearly as 5.42 ins. of the total July rainfall of 5.54 ins. fell before July 14th. From this date to September 2nd there were only 3.7 ins. all in small showers. There were over 3 ins. on September 2nd and then again until September 21st there were only small showers. From mid-July to September the ground was very dry and the cotton was unable to compete with the yams. Where native cotton was grown alone the stand was very good, but the Allen failed because of the dry spell that set in when it was sown.

TABLE No. 1.

Rainfall, 1928-29.

Month.	Ins., Rainfall.
1928.	
June	12·89
July	5·58
August	3·28
September	10·73
October	9·98
November	0·11
December	0·87
1929.	
January	0
February	0
March	0·63

The survey plots were supplied with seed on the following dates: – July 16th, August 7th and 31st, September 12th and 26th.

Table No. 2 shows the percentage stand at fortnightly intervals.

TABLE No. 2.

Date.	% Stand Ishan.	Munshi.
July 16th... ...	46	35
30th... ...	48	33
August 13th... ...	66	52
27th... ...	66	68
September 10th... ...	75	65
24th... ...	77	79
October 8th... ...	80	86
22nd... ...	77	82
November 26th... ...	76	77

No plants were seen to be damaged by the larvæ of *syagrus calcaratus*, F., but there was a certain amount of loss of young seedlings by cutworms and crickets.

Unless it be found that the past season's rainfall was unusual considerable advantage might be gained by planting the cotton in mid-June so that the plants might be well established before the "small dry" season.

Bud Shedding.

It is found impossible to determine the exact number of buds shed, but the methods employed are of use in comparing the two cottons. The total number shed and the percentage damaged by bollworms and those undamaged are shown in Table No. 3.

TABLE No. 3.

Bud Sheds.

Variety.	Total buds shed.	% without lesions.	% damaged by bollworms.
Ishan A.	9,170	78	15
Munshi	3,710	76	15

FLOWER PRODUCTION.

A.—Cotton through Yams.

TABLE No. 4.

Week ending.		No. flowers produced per week.	
		Ishan A.	Munshi.
October	27th	10	40
November	3rd	450	70
	10th	1,880	490
	17th	4,980	1,470
	24th	7,480	3,280
December	1st	5,270	4,000
	8th	3,560	4,060
	15th	1,590	2,500
	22nd	610	1,540
	29th	210	920
January	5th	660	990
	12th	2,800	2,450
	19th	1,400	990
	26th	980	620
February	2nd	580	330
	9th	370	410
	16th	480	280
	Total	33,310	24,440

B.—Cotton grown alone.

TABLE No. 5.

Week ending.	No. flowers produced per week.		
	Allen.	Ishan A.	Munshi.
September 22nd ...	896	0	0
,, 29th ...	1,904	56	224
October 6th	4,200	336	336
,, 13th	7,728	1,512	728
,, 20th	12,432	4,536	1,904
,, 27th	14,560	13,272	3,920
November 3rd ...	21,448	29,736	8,680
,, 10th ...	20,944	42,504	14,560
,, 17th ...	15,400	43,568	14,336
,, 24th ...	8,120	35,448	14,840
December 1st... ...	2,856	17,696	14,392
,, 8th ...	1,736	3,416	5,768
,, 15th ...	2,296	2,353	4,368
,, 22nd ...	2,800	1,120	3,752
,, 29th ...	12,152	2,240	1,344
January 5th	11,480	3,864	5,488
,, 12th	11,312	11,928	12,152
,, 19th	9,856	10,864	5,488
,, 26th	8,176	20,552	7,224
February 2nd ...	1,792	9,552	7,224
,, 9th	224	7,000	7,336
,, 16th ...	280	3,584	3,808
Total ...	172,592	264,600	147,336

It will be seen that the height of flowering of the Munshi is about two weeks later than that of the Ishan on both plots and that the cotton through yams is about two weeks later than when grown alone.

Boll Sheds.

TABLE No. 6.

	Ishan A.	Munshi.
Total No. bolls shed	13,880	5,390
% Flowers subsequently shed ...	41·6	22
% Sheds attacked by bollworms ...	4·5	5·5
% ,, ,, bugs	60	43·5
% ,, ,, bacteria ...	1	1
% ,, ,, alternaria ...	0·1	1
% ,, without lesions	29	40
% ,, unclassified	5	9

The difference in the percentage of flowers shed is very marked. that on the Ishan being nearly twice that on the Munshi. A greater percentage of the Ishan sheds were damaged by bugs while a greater number of Munshi sheds were undamaged.

Mummied Bolls.

Only three *per cent.* of Ishan and two *per cent.* of Munshi flowers subsequently mummified. Most of these were damaged by bugs.

HARVESTED BOLLS.

TABLE No. 7.

Period ending.	No. bolls harvested.	Lock Analysis:			
		% undamaged.	% damaged by:		
			Bollworm.	Bug.	Bacteria.
Ishan A.					
January 7th ...	539	54	8	32	3
February 18th ...	1,211	73	8	17	1
March 7th ...	212	70	22	7	0·5
Munshi.					5
January 7th ...	280	67	5	21	1
February 18th ...	1,338	80	5	13	1
March 7th ...	206	70	25	4	
Total Ishan ...	1,962	67	10	20	1
Total Munshi	1,824	77	8	13	1·5

Anthracnose was only observed on one Munshi boll affecting two locks.

It will be seen that bugs were the important factor in the first period but that bollworms increased greatly at the end of the season. Ishan suffered from both these pests more than the Munshi.

Yields.

Owing to the low boll production yields were not estimated from the small survey plots but the plantation yields from the whole block are given in Table No. 8.

TABLE No. 8.

AVERAGE YIELDS PER ACRE FROM FIVE-QUARTER ACRE PLOTS.

Period ending.	Weight of seed cotton in lb.		
	Clean.	Stained.	% Stained.
ISHAN A.			
January 10th	27·5	3	10
February 9th	31	2·5	7·5
March 6th	8·5	0	0
MUNSHI.			
January 10th	22	3	14
February 9th	42·5	3·5	7·5
March 6th	15·5	1	0·5
Total Ishan	67	5·5	7·5
Total Munshi	80	7·5	8·5

Harvesting was concluded on March 6th. On the 7th there were the following number of bolls left on the plants per acre :—
Ishan, 180; Munshi, 360.

INSECT INCIDENCE.

A.—STAINER GAUGE.

The stainer infestations on the various plantation cotton plots were very variable. The only block where they were numerous was on B. 1. where the three varieties, Allen, Ishan A., and Munshi were grown alone and where the stainer gauge was taken. Before the cotton came into maximum, flower stainers were swarming on the unripe heads of guinea-corn in an adjacent block, and as the guinea-corn dried off the stainers moved across to the cotton, first of all to the Allen and then to the native varieties. The stainers seemed most numerous on the guinea-corn at the end of October. On November 1st, 102 adult stainers were collected from five average heads and nymphs were also abundant.

Stainers were practically absent from all the other blocks of cotton. Not ten stainers were seen throughout the season on the cotton in the C. 6 block where the survey was carried out.

The stand of Allen on B. 1 was very poor and the Allen stainer figures cannot be compared with those on the native varieties but are given to show the time of arrival of stainers in the block. The native varieties attracted very few of the first migration of the yellow type of stainer and only suffered from the progeny of those attracted to the guinea-corn and Allen cotton.

TABLE No. 9.

THE STAINER GAUGE.

Date.	No. of Stainers per ⅛ acre.		
	Allen.	Ishan A.	Munshi.
September 20th	0	0	0
„ 27th	3	1	0
October 4th	1	0	10
„ 11th	504	2	39
„ 18th	154	3	4
„ 25th	531	7	81
November 1st	272	214	55
„ 8th	170	43	31
„ 15th	66	10	11
„ 22nd	160	325	215
„ 29th	468	633	357
December 6th	479	924	646
„ 13th	336	928	876
„ 20th	117	312	393
„ 27th	23	101	107
January 3rd	3	11	10
„ 10th	2	0	2
„ 17th	0	0	0
Total	3,289	3,514	2,837
No. plants per acre ...	2,560	3,320	3,224

Only two species of *dysdercus* were found. By far the commonest was *superstitiosus*, but in the latter half of the November and the first half of December a number of *fasciatus* were taken: 101, 282, and fifty-three from the Allen, Ishan A. and Munshi respectively. Very few indeed of the banded from of *superstitiosus* were taken.

Observations were kept on stainers in the Munshi country through the wet season of 1927 and they seemed to be much more abundant than in the Oyo Province at this time of the year. Gero

or bullrush millet is grown extensively and stainers were found to breed upon it. In July, 1927 a stainer gauge was taken upon this crop on the Yandev Plantation. On July 14th, 184 adults were taken from an eighth acre. After the gero was uprooted the stainers moved to an adjacent field of maize (*see* Golding, (1), page 330). For the greater part of the wet season they have a plentiful supply of food plants in the Benue Province. Although there are no baobab, *adansonia digitata*, the white silk cotton tree, *eriodendron orientale*, is very common and is largely used as a shade tree.

B.—Plant Bugs.

Golding (2) first pointed out the importance of " plant bugs ", mainly *pentatomidæ*, to the cotton crop in Nigeria at Ilorin.

As has been stated stainers were practically absent from the survey plots in C. 6 and yet analysis of damage to shed bolls (Table No. 6) shows that a large proportion of sheds were punctured by bugs. The analysis of harvested locks (Table No. 7) also shows that bugs caused considerably more damage than the other pests. Rhynchota other than *dysdercus* were however common.

In early December 106 bugs were taken feeding on bolls of Ishan and Munshi cotton on C. 6 of which the following 105 have been identified :—

Pyrrhocoridæ—	
Dysdercus superstitiosus, F.	3
Pentatomidæ—	
Halydicoris scoruba, Dall.	63
Piezodicoris scoruba, Germ.	22
Nezara viridula, L.	2
Steganocerus multipunctatus, Thnbg., var. *argus*, F.	2
Menida sp.	2
Mecosoma mensor, Germ.	1
Coreidæ—	
Acanthomia sp.	6
Anoplocnemis curvipes, F.	3
Cletus sp.	1

Callidea natalensis, St. was also seen on the cotton.

In February all rynchota were very scarce.

C.—Bollworms.

The following four species of bollworms were found on the cotton :—

Diparopsis castanea, Hmps.
Earias insulana, Boisd.
Earias biplaga, Walk.
Argyroploce leucotreta, Meyr.

Over fifty *per cent.* of all bollworms taken were *D.castanea* and of the two species of *earias*, *insulana* was the commoner especially towards the end of the season.

In August *A.leucotreta* was breeding in great numbers in maize cobs in the field. *Heliothis obsoleta*, F. was found on maize and tomato but not on cotton.

D.—Other Insect Pests.

Jassids were very rare as also *helopeltis* spp. A few nymphs of *helopeltis* were found feeding on cotton.

The Leaf Roller, *sylepta derogata*, F., was common but caused no serious damage. Counts showed it to be considerably more abundant on the Ishan than on the Munshi or Allen.

OTHER DISEASES.

A.—Leaf Curl.

This virus disease was very rare, less than 0.1 *per cent.* of the native cotton plants being attacked.

B.—Leaf Roll.

This disorder was common and counts were taken in October and November on Munshi cotton sown at three different times and on Allen, Ishan and Munshi in the variety test..

TABLE No. 10.

Percentage of Plants attacked by Leaf Roll.

Variety.	Date Sown.	Dates Examined.		
		October 8th.	October 19th.	November 9th.
Munshi ...	July 3rd	0·8	3·0	10·4
„ ...	„ 16th	0·2	0·8	5·9
„ ...	August 2nd	0·1	0·1	2·6
Allen ...	July 16th	0·3	1·2	0·9
Ishan ...	„ 4th	2·6	23·5	19·2
Munshi ...	„ 3rd	0·4	5·0	5·1

SUMMARY AND CONCLUSIONS.

A study has been commenced of the factors that influence the production of cotton in the Benue Province. The improved Ishan A. from Ibadan has been compared with the indigenous Munshi cotton when grown through yams.

The present experiment was undertaken under very poor conditions, with small plants and low flower production, conditions that are rather typical of the average Munshi farm.

Drought in July and August was the most important factor as it was impossible to secure a good stand of cotton through yams.

Under these conditions the Munshi cotton was more successful than the Ishan. In spite of the fact that the Ishan shed nearly three times as many buds as the Munshi it produced many more flowers. As however the Ishan shed nearly twice as many bolls as the Munshi, about the same number of bolls were harvested. Further as fewer Munshi bolls were damaged the final yield was considerably greater from the Munshi cotton.

The Munshi cotton seems to enjoy the following advantages over the Ishan A.

1. Many fewer buds shed. Table No. 3.
2. Many fewer bolls shed. Table No. 6.
3. Bolls attacked less by bugs and bollworms as shown by analysis of sheds and harvested bolls. Table Nos. 6 and 7.
4. Slightly fewer bolls mummify.
5. Less attractive to stainers. Table No. 9.
6. Much less susceptible to Leaf Roll. Table No. 10.
7. Not so attractive to the Leaf Roller.

The Ishan produces more flowers, Table Nos. 4 and 5, and the lint is probably more valuable although it has been found that when grown in the Benue Province the Ishan A. is not of the same high quality as when grown at Ibadan.

It seems therefore, on the first years results, that it is most unlikely that Ishan A. is suitable for replacing the Munshi cotton.

ACKNOWLEDGMENTS.

In conclusion the writer wishes to acknowledge the assistance of Mr. F. D. Golding who originally planned the experiment, and to Messrs. I. E. James and J. F. Ward for assistance at Yandev.

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THE ISHAN COTTON PLANT UNDER MIXED CULTIVATION—I.

BY

C. B. TAYLOR, E. H. G. SMITH AND C. J. LEWIN.

Mixed cultivation is one of the most important characteristics of farming practice in Southern Nigeria. Usually each heap or ridge in native farms contains two or three different crops and pure cultivation is comparatively rare. As a rule cotton is planted during July through established yams or maize, or occasionally late maize is planted in September through existing cotton, when the latter had been planted as a sole crop. The following censuses of cotton areas, made by the Agricultural staff during the 1927-28 season, are probably typical of the general practice in the Western Provinces:—

	Meko.	*Oyo.*
Cotton through yams	40%	41%
Cotton through early maize ...	45%	46%
Cotton through other crops ...	3%	—
Cotton as a sole crop	12%	13%

It will be readily understood, therefore, that the first essential of a new cotton for introduction to the Southern Provinces is that it shall be amenable to intercropping. In this connection it may be mentioned that a contributory, if not the most important, cause of the rejection of Allen cotton by native farmers was its failure in this respect.

An attempt to improve the quality of cotton in the Southern Provinces was commenced in 1924 by means of selection within the characteristic cotton of the Ishan district. This Ishan cotton, like all other indigenous types, has been evolved under varying systems of mixed cultivation and is therefore suited to this practice. The cotton used in this investigation was a pure improved strain of Ishan cotton, which is now generally distributed among farmers in the Oyo and Abeokuta Provinces.

Little is known of the effect of intercropping on the cotton plant. Trials at Ilorin and Ibadan during the last few years have shown that it results in a general decrease in cotton yield. Golding (2) has investigated the subject from an entomological standpoint at Ilorin and has found that the early crop of interplanted cotton was cleaner than that of cotton grown alone. The authors were of the opinion that a somewhat detailed study of the effects of intercropping, leading to an analysis of the causes of decreased yield, would be desirable. It was decided to initiate an experiment wherein alternating plots of pure cotton and of yams interplanted

with cotton should afford a means of comparing the cotton plant under pure and mixed cultivation. Yams were chosen for this investigation rather than maize as, with the former, the period of competition extends until October, while the latter is removed in August. However it will probably be necessary to repeat the experiment later using both early and late maize and possibly groundnuts in addition. The average cotton yields in Southern Nigeria vary enormously from season to season. The causes of this fluctuation may undoubtedly be ascribed, partly to the varying incidence of insect pests, and partly to the direct effect of climatic factors, of which the distribution of rainfall is probably the chief. Approximately once in five years a disastrous season occurs such as that of 1927-28, which, however, was followed by an exceptionally favourable cotton year. Hence it is necessary that a study of this kind should extend over at least two, and preferably over several, seasons. This first paper of the series outlines the methods adopted and gives the results obtained during the 1928-29 season.

METHOD.

A piece of land was thrown into ridges seventy-two feet in length and six feet apart. Yams of the " Alade " variety were planted throughout on February 20th, 1928, the distance between stands being two feet. The yams were staked as soon as shoots appeared. On June 30th, the yams in alternate series of three rows were uprooted, and on July 11th, cotton was planted throughout the field, the stands being two feet apart. The field thus consisted of alternating yam-cotton and pure cotton plots, each plot consisting of three rows. Hereafter, for convenience, these will be referred to as YC and C plots respectively. There were seven replications of each treatment and the field may be represented thus :—

Border	(1 row of YC).
YC	Rows 1, 2, 3.
C	,, 4, 5, 6.
YC	,, 7, 8, 9.
C	,, 10, 11, 12.
YC	,, 13, 14, 15.
C	,, 16, 17, 18.
YC	,, 19, 20, 21.
C	,, 22, 23, 24.
YC	,, 25, 26, 27.
C	,, 28, 29, 30.
YC	,, 31, 32, 33.
C	,, 34, 35, 36.
YC	,, 37, 38, 39.
C	,, 40, 41, 42.
Border	(2 rows of YC).

The following observations were made:—

1. *Growth Rate of Main Axis.*—Stem heights were measured weekly from August 18th until December 15th, when the weekly increments had become insignificant. Five plants in the middle row of each YC and C plot were measured.

2. *Extent of Vegetative System.*—The length of the vegetative branches of those plants used for stem heights was measured on November 5th, just before the yams were harvested, and again on January 8th when the first cycle of growth of the main axis had practically ceased.

3. *Flowering.*—A daily record was kept of the number of flowers produced on the middle row of each plot.

4. *Square Shedding.*—The extent of square shedding on the first five fruiting branches of the middle row plants of each plot was assessed at the time of the general commencement of flowering.

5. *Bolling.*—Number of bolls harvested weekly from the middle row of each plot was recorded. The mean weight of seed cotton per boll was calculated.

6. *Yield.*—The weight of seed cotton harvested weekly from every row in the plot was recorded.

7. *Mean Maximum Lint Length.*—For a period of three weeks, weekly measurements were made on a carefully drawn sample of seed cotton from each middle row.

8. *Ginning Percentage.*—This was determined for a period of three weeks by means of a 4″ hand roller gin (Platt Bros.), on seed cotton from each middle row.

9. *Observations on Yams.*—The weight per row of yam tubers was obtained, and the mean date of the dying down of the vines was recorded.

10. *Disease.*—A periodical assessment of the incidence of cotton diseases was made throughout the season.

11. *Rainfall.*—A daily record was maintained from the beginning of June until the end of the season.

Results.

The results obtained in the various stages of the investigation will be presented in the following order:—

1. Growth of the Plant Body.
2. Flowering.
3. Shedding.
4. Bolling.
5. Yield.
6. Lint Length.
7. Ginning Percentage.
8. Disease.

A discussion and summary of the results will follow.

1.—Growth of the Plant Body.

(*a*) *Growth of the Main Axis.*—The height of the main stem (measured from the cotyledonary node) was determined weekly on approximately five plants in each middle row, and the mean of three independent measurements recorded in each case. The results, based on the mean of some thirty-five plants in each group, are summarised in Table I. and are also presented graphically (Fig. I.). It will be noted that on August 18th, when the measurements were commenced, the mean height of YC was but sixty-eight *per cent.* of that of the C group. Until the middle of October C grew more rapidly than YC, but thereafter, with one exception, the weekly increment of the latter exceeded the former; so that by December 15th, when growth had almost ceased, YC was ninety-one *per cent.* of C. Observations on yam vines showed that roughly seventy-five *per cent.* had commenced to wither by the end of September and that three weeks later about the same proportion had definitely died, while the remainder were withering. It seems likely, therefore, that as the yams ceased to be of importance as a competitive factor, the YC plants, hitherto held back, were not so near senescence as those of the C group and were thus able to respond by more rapid growth from October 20th onwards. The lower graph shows a curious depression in the YC incremental curve (during the weeks ending October 29th, and November 3rd), which is not reflected by that of the C group. No satisfactory explanation of this can be given, but it is not of sufficient magnitude to have an appreciable effect on the growth curve shown in the upper graph. While the actual growth rate of YC was slower than that of C until the middle of October, when the growth rates relative to the height attained at any time are compared, it is found that the former is constantly in excess of the latter (*see* column 3 of Table I where the weekly

increments are expressed as percentages of the mean height for the previous week). This, together with the trend of the two incremental growth curves, suggests that intercropping exercises a simple retardation effect on the growth of cotton. It is found (*see* upper graph) that if the growth curve of C is postdated by nine days and applied to that of YC, there is a tolerable agreement between the two until the beginning of November, after which the latter falls steadily away from the former. Actually, at this time YC was growing faster than C, but not so fast as the latter group was growing nine days previously. Although the YC and postdated C curves appear to fit fairly well until November, it is doubtful if the effect of intercropping may be assessed as a simple retardation of nine days until the onset of flowering, for the velocity constants of the two growth curves differ markedly. However, it is evident that the first six weeks are all important in the life of the plant, for the YC group was never able to recover from the initial retardation it sustained during this period.

TABLE I.

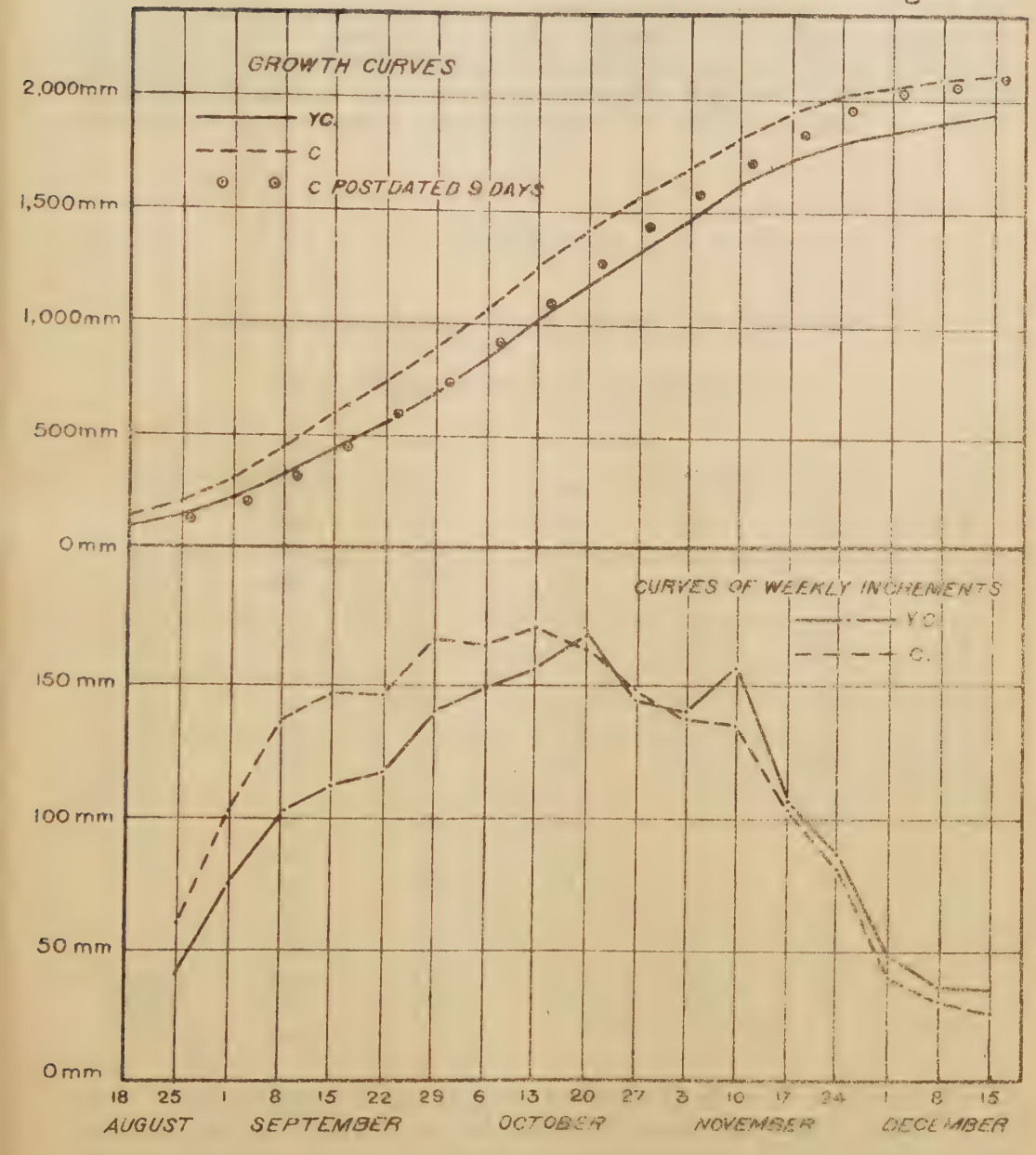
Growth of Main Axis.

Note.—The measurements are recorded in millimetres. The records were compiled on certain plants in the middle rows of the YC. and C. plots.

Date.	I. Mean Height.		II. Weekly Increments.		III. Percentage Increase.	
	YC.	C.	YC.	C.	YC.	C.
18th August ...	99	146	—	—	—	—
25th „ ...	142	209	43	63	43	43
1st September	221	316	79	107	56	51
8th „ ...	326	453	105	137	48	43
15th „ ...	443	601	117	148	36	33
22nd „ ...	565	748	122	147	28	24
29th „ ...	705	918	140	170	25	23
6th October ...	855	1,085	150	167	21	18
13th „ ...	1,013	1,259	158	174	18	16
20th „ ...	1,184	1,425	171	166	17	13
27th „ ...	1,329	1,573	145	148	12	10
3rd November	1,470	1,710	141	137	11	9
10th „ ...	1,627	1,845	157	135	11	8
17th „ ...	1,738	1,952	111	107	7	6
24th „ ...	1,828	2,037	90	85	5	4
1st December...	1,878	2,079	50	42	3	2
8th „ ...	1,916	2,112	38	33	2	2
15th „ ...	1,953	2,139	37	27	2	1

GROWTH OF THE MAIN AXIS

Figure I



DRAWN & REPRODUCED BY NIGERIA SURVEYS, LAGOS, 1929.

(*b*) *Growth of Vegetative Branches.*—The lengths of vegetative branches of those plants, whose stem heights have already been recorded, were measured on November 5th, just before the yams were harvested, and again on January 8th, by which time the first cycle of growth had practically ceased. The figures given in Table II are the mean lengths of the first eight vegetative branches. It was impossible to include figures for higher branches as the number of these varied considerably from plant to plant.

TABLE II.

Growth of First Eight Vegetative Branches.

(The lengths are given in centimetres.)

	YC.			C.		
No. of Branch.	Length on Nov. 5th.	Length on Jan. 8th	Increase.	Length on Nov. 5th.	Length on Jan. 8th.	Increase.
1.	40	50	10	67	71	4
2.	50	62	12	82	91	9
3.	66	83	17	93	97	4
4.	64	78	14	85	96	11
5.	64	76	12	89	96	7
6.	77	81	4	88	92	4
7.	64	80	16	87	97	10
8.	74	86	12	87	92	5
Mean	62	74	12	85	92	7

Calculations from this table show that on November 5th the YC vegetative branches averaged seventy-three *per cent.* of the length of those of C. Reference to the stem height records will show that the retarding effect of yam competition practically ceased by the middle of October. It is therefore likely that this figure of seventy-three *per cent.* is slightly too high to be truly representative

of the relative growth of the vegetative systems at the end of the period of intercropping effect. By January 8th, due to more rapid growth, the YC group had attained to eighty *per cent.* of the average C length, the YC vegetative branches having increased by 12 cms. (twenty *per cent.*) against an average increase of 7 cms. (eight *per cent.*) in the case of C.

In both groups and on both dates (*i.e.*, November 5th and January 8th) positive correlations existed between the height of the main axis and total length of the vegetative system. The co-efficients and their standard errors are :—

YC (November 5th)	$r = .82 \pm .008$
C (November 5th)	$r = .52 \pm .020$
YC (January 8th)	$r = .47 \pm .024$
C (January 8th)	$r = .45 \pm .029$

A correlation, either positive or negative, between plant height and the extent of the vegetative system would be expected in members of a pure strain grown under identical conditions for, whatever their size, the plants would be more or less of the same shape. These co-efficients show that the same general shape of the plant was maintained throughout the plot; thus, in this experiment, intercropping was without effect on habit.

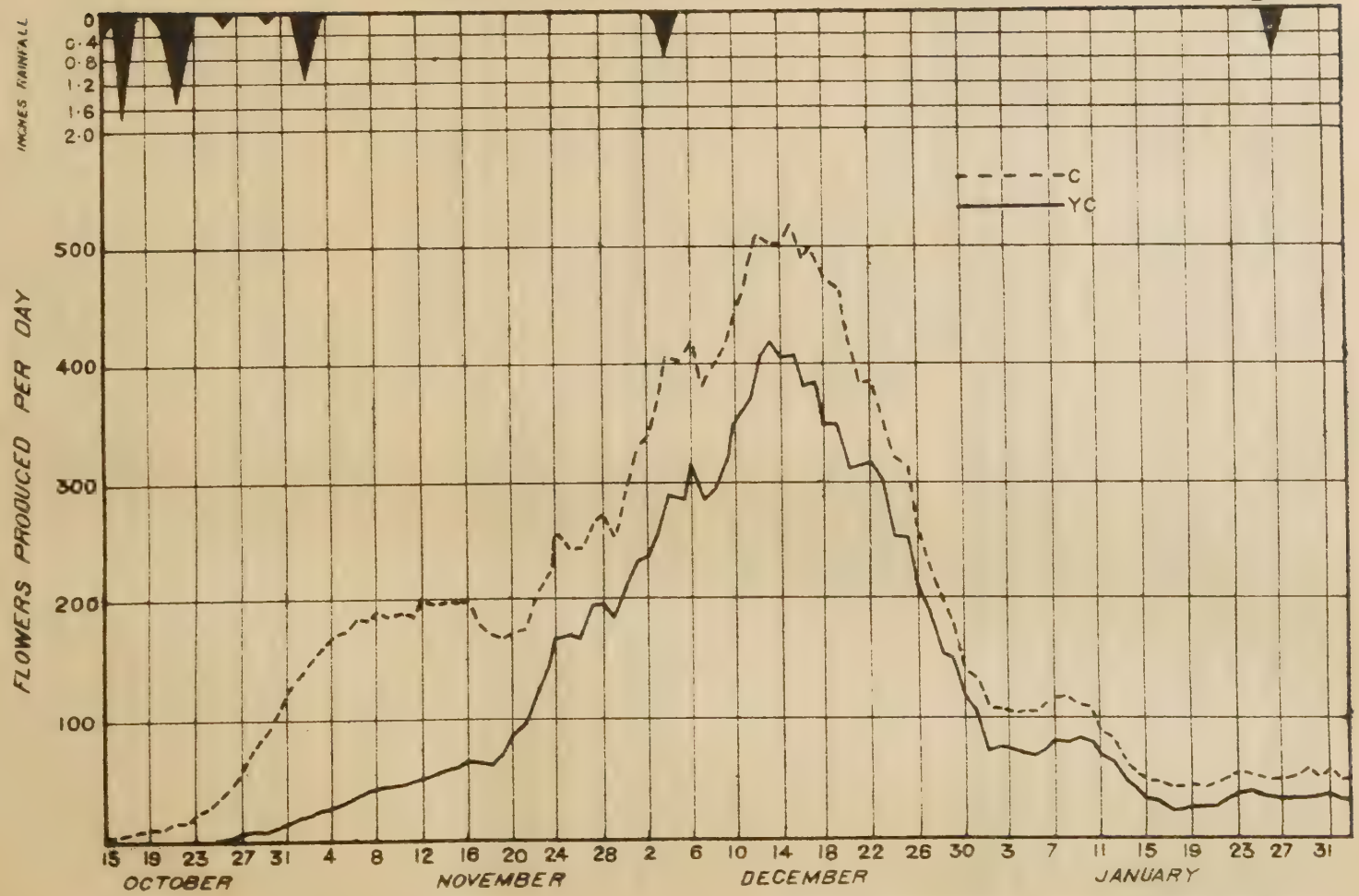
II.—Flowering.

Daily counts were made of the number of flowers produced on the middle row of each plot. These are summarised in Table III as weekly totals. The ratios YC : C flowers are expressed as percentages in the final column. It will be seen that the ratio is low for the first five weeks of flowering but that during the week ending November 24th a sudden jump to fifty-six occurs and in the following week seventy-two is reached. Thereafter the ratio remains in the neighbourhood of seventy and taking the season as a whole the YC flowers were sixty-five *per cent.* of the total of C.

FLOWERING CURVES

(Smoothed by using overlapping 5 day means)

Fig. II.



DRAWN & REPRODUCED BY NIGERIA SURVEYS, LAGOS, 1929.

TABLE III.

Totals of Flowers produced per week on the Middle Rows.

Week Ending.	YC.	C.	$\frac{YC \times 100}{C}$
20th October	—	39	—
27th „	14	203	7
3rd November	109	847	13
10th „	277	1,338	24
17th „	421	1,412	30
24th „	789	1,423	56
1st December	1,338	1,849	72
8th „	2,174	2,970	73
15th „	2,709	3,362	81
22nd „	2,411	3,232	75
29th „	1,712	1,952	88
5th January	530	754	70
12th „	580	827	70
19th „	239	360	67
26th „	266	373	71
2nd February	254	385	66
Total	13,823	21,326	65 (Mean)

In Fig. II the flowering curves of the two groups are shown, drawn from overlapping five-day means. With the exception of the first six weeks, the agreement between the two groups, even in minor peaks and depressions, is remarkable; thus, for example, the isolated rainfall which occurred on December 4th is followed by a simultaneous drop in flowering of YC and C. YC corresponds very closely to a normal curve with the mode occurring in the middle of December. The C curve, on the other hand, rises sharply from October 25th till November 4th and thereafter remains flattened for a fortnight after which its trend is parallel to that of YC. The premature rise in the C curve is peculiar to the season, for we are informed by Mr. Golding that it occurred also in the case of other cotton grown on Moor Plantation. Usually no serious rise in the flowering curve of native cottons occurs before the cessation of the rains, as the plant delays its flowering by the shedding of its squares until the onset of the dry season. This question will be discussed at greater length under " Shedding ".

Although the YC flowering was apparently retarded at first, yet the peaks of the two flowering curves are coeval, each occurring during the week ending December 15th. This behaviour is somewhat remarkable and is at variance with the results obtained by

Golding (2) at Ilorin in 1927-28, who found that competition with yams resulted in a three weeks lag in the flowering curve. The discrepancy may be due to seasonal differences, to differences between the Ibadan and Ilorin environments or to a superior growth of yams at Ilorin. In the present experiment, the immediate competitive effect of yams was not sufficiently prolonged to delay the cotton after the first six weeks of flowering though a general depression in rate of flowering was maintained throughout the season.

III.—Shedding.

In cotton investigations of this kind an estimate of the extent and causes of shedding is beset with difficulties, demanding detailed observations on each plant and indeed on each square and boll. Moreover, the conclusions are liable to be vitiated by the fact that the cotton plant sheds a considerable proportion of its squares and young bolls for physiological reasons. The proportion of undamaged bolls shed is usually comparatively low; but this is not necessarily a measure of the extent of " physiological " shedding, as many of the shed bolls showing lesions might conceivably have been shed from physiological causes, even had there been no external biological intervention. In the present experiment no attempt was made to assess insect or fungoid damage, either as a cause of shedding or on the harvested crop.

(*a*) *Square Shedding.*—The extent of square shedding on the first five fruiting branches of all middle row plants was estimated by a census of the number of nodes and of the shedding scars on these branches. In order to avoid the inclusion of boll shedding it was necessary to make the census at the commencement of the flowering period; this was done on October 31st for the C group, and on November 12th in the case of YC. By these dates C had produced an average of one flower per plant and YC. two flowers per plant. The rusults are as follows :—

	YC (Nov. 12th).	*C (Oct. 31st).*
Total No. of Nodes	9,200	9,345
Total No. of Shed Scars ...	3,712	3,807
Shedding percentage ...	40.3	40.7

This agreement in the incidence of square shedding up to the time of the general commencement of flowering of the two groups is indeed remarkable. Reference has already been made to the fact that the indigenous cottons of Southern Nigeria usually delay their flowering by square shedding until the onset of the dry season. This being the case it might reasonably be expected that the incidence of square shedding on the C group would be in excess of that on YC,

for the former was in a more advanced stage of development than the latter during the early part of the season. Nevertheless the extent of shedding is identical in the two groups, a fact which accounts for the peculiar " bulge " in the C flowering curve during the first half of November. From the data available it would be idle to surmise why the incidence of square shedding on C is so low, but as has already been suggested, the type of flowering curve shown by C is peculiar to the season and presumably some subtle environmental factors militated against square shedding during the later rains. This is substantiated, to some extent, by the comparatively slight incidence of shedding on both groups, for usually square shedding on indigenous cottons early in the season is extremely severe; *e.g.*, Lewin and Mason (1) found that the percentage of shed scars on the first five fruiting branches of Ishan cotton in 1924 varied between thirty-three and ninety-eight, the mean for 370 plants being seventy-six *per cent.*

(*b*) *Boll Shedding.*—While no direct assessment of the extent of boll shedding was made, the total shedding on the two groups may be compared in the following way :—

	YC.	*C.*
Total No. of flowers produced ...	13,823	21,326
Total No. of Bolls produced ...	7,400	11,000
Boll Shedding by difference ...	6,423	10,326
Percentage sheds to flowers ...	47%	48%

The figure " Boll Shedding by difference " also includes bolls which were not abscissed but which gave no seed cotton, *i.e.*, mummied bolls and totally damaged bolls. The number of these, however, was comparatively insignificant in this experiment. A rough indication of the trend of shedding throughout the season may be obtained by substracting the weekly totals of bolls produced from the weekly totals of flowers, the boll totals being antedated by an appropriate interval to bring them opposite the flowers which might reasonably be expected to have produced them. Such an interval can but be an approximation, for the period from flowering to boll opening is by no means constant. Hitherto unpublished data, obtained by Lewin in 1925-26, showed that for Ishan cotton the period varied between forty-four and sixty-four days the mode being fifty-four days and the mean approximately the same. In the computation of this figure the date of the first splitting of the loculi was taken as the end-point. Bolls would not be harvested at this stage but would be ready for picking two or three days later. Hence a period of eight weeks has been assumed in the present investigation.

The results obtained by comparing flowering and bolling when the boll figures have been antedated eight weeks are given in Table IV.

TABLE IV.

Weekly Assessments of Boll Shedding on Middle Rows.

Note.—November 17th for flowers corresponds to 12th January for Bolls and so on.

Week ending (for flowers).	Yc.				C.			
	No. of flowers.	No. of Bolls.	Bolls shed (by difference.)	Approx. % Bolls shed.	No. of flowers.	No. of Bolls.	Bolls shed (by difference.)	Approx. % Bolls shed.
17th November	421	162	259	60	1,412	437	975	70
24th ,,	789	332	457	60	1,423	530	893	60
1st December	1,338	609	729	55	1,849	721	1,128	60
8th ,,	2,174	810	1,364	65	2,970	1,148	1,822	60
15th ,,	2,709	1,287	1,422	50	3,362	1,681	1,681	50
22nd ,,	2,411	1,345	1,066	45	3,232	1,896	1,336	40
29th ,,	1,712	989	723	40	1,952	1,373	579	30
5th January ...	530	683	—	—	754	991	—	—
12th ,, ...	580	510	70	10	927	750	77	10
19th ,, ...	239	235	4	—	360	424	—	—
26th ,, ...	266	230	36	15	373	438	—	—

It will be seen that the weekly percentage of bolls shed to flowers produced in the two groups is remarkably constant throughout the season. Unless, throughout the plot, a perfectly uniform distribution of insect and fungoid pests can be conceded (and this seems highly improbable), the similarity of shedding in the two groups may be taken as evidence that at no time was the level of "physiological shedding" exceeded, *i.e.*, that the same incidence of abscission would have occurred even in the entire absence of pests and diseases. If this hypothesis is correct, the level of "physiological shedding" in both groups is extremely high (about eighty *per cent.*) at the commencement of the flowering period and declines in a fairly uniform manner until it becomes practically nil at the end of the season.

IV.—Bolling.

The number of bolls harvested weekly from middle rows was recorded from January 12th onward. (Table V.). Previous to this date two pickings had been made but the number of bolls was not counted. However, a close approximation to the number actually picked may be obtained by calculation from the mean boll weight and the yield figures for the weeks ending December 29th and January 5th (Table VII.). These calculated figures have been included at the foot of Table V.

TABLE V.

Number of Bolls harvested weekly from Middle Rows and Mean Weight per Boll in grammes.

Week ending.	YC. No. of bolls.	YC. Mean weight per boll.	C. No. of bolls.	C. Mean weight per boll.
12th January ...	162	2.39	437	2.32
19th January ...	332	2.38	530	2.13
26th January ...	609	2.35	721	2.40
2nd February ...	810	2.89	1,148	2.78
9th February ...	1,287	2.61	1,681	2.73
16th February ...	1,345	2.47	1,896	2.56
23rd February ...	989	2.29	1,373	2.35
2nd March ...	683	2.27	991	2.17
9th March ...	510	1.83	750	2.14
16th March ...	235	1.89	424	2.11
23rd March ...	230	1.68	438	1.75
Total No. of bolls counted ...	7,192		Total No. of bolls counted ...	10,389
Approximate No. of bolls from first two pickings (by calculation)	208		Approximate No. of bolls from first two pickings (by calculation)	611
Total bolls produced ...	7,400		Total bolls produced ...	11,000
Mean boll weight ... 2.39 gr.			Mean boll weight ... 2.42 gr.	

From the above table it will be seen that—

(i) Like the flowering curve maxima, the bolling peaks are coeval.

(ii) YC plants produced sixty-seven *per cent.* of the number of bolls of C.

(iii) The mean boll weight for the two groups is approximately the same, and in each case there is a gradual decline in boll weight from the second week in February till the end of the season.

V.—Yield.

The total yields of seed cotton from each row are given in Table VI. It will be noted that each C plot gave yields considerably in excess of the adjoining YC plots with the exception of that plot composed of rows forty to forty-two. This may undoubtedly be ascribed to poverty of soil since, at this end of the field, the fertility of the soil, as reflected both by cotton and yam yields, showed a

progressive decrease from row thirty-seven onwards. As would be expected from the bolling records, the total YC yield is approximately sixty-seven *per cent.* of that of C. There is no correlation between the yields of yams and cotton in the YC rows.

TABLE VI.

YIELDS OF SEED COTTON (IN OUNCES) FROM YC AND C PLOTS.

(*The figures in italics are yam yields in pounds.*)

YC.			C.		
Row No.	Row Yield.	Plot Yield.	Row No.	Row Yield.	Plot Yield.
1 2 3	78 [*57*] 55 [*53*] 88 [*47*]	221 [*157*]	4 5 6	128 173 173	474
7 8 9	100 [*50*] 102 [*75*] 102 [*58*]	304 [*183*]	10 11 12	136 161 184	481
13 14 15	147 [*66*] 118 [*74*] 122 [*55*]	387 [*195*]	16 17 18	154 170 168	492
19 20 21	90 [*75*] 84 [*64*] 89 [*83*]	263 [*222*]	22 23 24	134 119 166	419
25 26 27	71 [*69*] 95 [*87*] 89 [*92*]	255 [*248*]	28 29 30	140 149 162	451
31 32 33	117 [*80*] 114 [*58*] 81 [*58*]	312 [*196*]	34 35 36	129 104 116	349
37 38 39	67 [*36*] 59 [*67*] 58 [*50*]	184 [*153*]	40 41 42	73 67 44	184
Total YC.	—	1926 [*1354*]	Tota C ...	—	2850

The table also enables an estimate to be formed of the " border effect " of yams. If the effective foraging range of the yam plant exceeded the spacing distance of the rows (six feet) it would follow that the yields of the middle YC rows would be unduly depressed, and conversely, that the middle C rows, being those farthest removed from yam competition, would be higher than the

two adjoining outside C rows. This, however, is not the case. The mean yield per row of the outside YC rows is 92.5 oz. while that of the middle YC rows is 90 oz. Similar figures for the outside and middle C rows are 136 and 135 respectively. Thus it may be concluded that the competitive effect of yams did not extend beyond a distance of three feet on either side of the ridge.

The effect of intercropping on the delivery of the cotton crop is shown in Table VII.

TABLE VII.

Comparison of weekly Pickings on Middle Rows throughout the Season.

(*The weights are expressed in grammes.*)

Week ending.	Yield of YC.	Yield of C.	Approximate % of total crop YC.	C.
29th December ...	298	850	2	3
5th January ...	184	620	1	2
12th January ...	387	1,013	2	4
19th January ...	790	1,129	4	4
26th January ...	1,431	1,732	8	7
2nd February ...	2,340	3,195	13	12
9th February ...	3,360	4,590	19	17
16th February ...	3,318	4,860	19	19
23rd February ...	2,260	3,230	13	12
2nd March ...	1,548	2,150	9	8
9th March ...	931	1,605	5	6
16th March ...	465	895	3	3
23rd March ...	387	767	2	3

As would be expected the period of maximum delivery is the same for each group. Weekly figures for the two series are closely similar when expressed as percentages of the total crop in each case, though YC shows a slight lag for the first three weeks.

VI.—Lint Length.

The mean maximum lint length (based on sixty measurements) of samples drawn from the seed cotton of middle rows was determined for three consecutive weeks commencing on January 30th. It has been calculated that for this number of measurements a difference of 0.5 mm. is significant. The results were as follows:—

TABLE VIII.

Mean Maximum Lint Length (in millimetres).

Date.	*YC.*	*C.*
January 30th ...	34.4	34.6
February 2nd ...	35.6	35.9
February 13th ...	35.1	35.0

While there is no significant difference between the two groups, the two rise and fall together and the magnitude of the weekly fluctuations is statistically significant. It is unfortunate that the series of observations was limited to three weeks.

VII.—Ginning Percentage.

Determinations of ginning percentage were made on the seed cotton from middle rows and the following results were obtained:—

	YC.	*C.*
January 9th ...	33.9%	34.8%
January 16th ...	32.1%	34.8%
January 23rd ...	33.6%	35.4%

Unfortunately, these are the only records available and, while no definite conclusion can fairly be drawn from them, there is a distinct indication that intercropping reduced the proportion of lint to seed.

VIII.—Disease.

The season was characterised by a remarkable degree of freedom from direct insect damage and from insect borne fungous diseases. Bacterial disease of the leaves, which later extended in some cases to branches, was the only serious disorder. This eventually effected every plant in the field but the severity of attack was less marked on YC plants.

Discussion of Results.

Before discussing these results and drawing conclusions from them, it is necessary to reiterate the need for caution in dealing with data collected during the course of a single season. Not only was the season under review exceptionally favourable to cotton, but also the yams, planted somewhat late, did not exert the same degree of competitive effect as has been noted in other trials. For example it has been observed that, in the case of a thick cover of yam vines, the interplanted cotton is liable to etiolation during its early stages of growth. This did not occur during the course of the present investigation. But it is in a season characterised by drought during the period that the cotton is in seedling stage, that the effect of yam competition is most marked. This was particularly noticeable on native farms on the Meko plateau during the 1927-28 season, when a drought occurred for over six weeks after the date of planting. At the time of planting the ground was sufficiently moist to cause excellent germination but thereafter the seedlings were entirely dependent on the upward movement of water in the yam hills. As the yams were growing vigorously at the time, the seedlings obtained barely sufficient moisture to support life, and were prevented from making sufficient root growth to enable them to tap water from the lower levels. Many of the seedlings were killed outright and those that were left failed to make a complete recovery when the rains came. Thus it must be understood that many of the conclusions drawn at this stage of the investigation are probably applicable only to the season under review.

The results show that the effect of intercropping was to depress growth, flowering, bolling, yield and possibly ginning percentage. Intercropping had no apparent effect on square or boll shedding, on the rate of delivery of the crop, on boll weight, on lint length, or on the shape of the plant; and the effect of the yam competition was confined to the ridge on which the yams were growing. Throughout the investigation a figure of the order of seventy *per cent.* represents the achievment of intercropped cotton in comparison with pure cotton. This is true for the growth of the plant body up to the time of the cessation of the yam effect; for flowering, and because shedding was similar in the two groups, for bolling also; finally, since the mean boll weight was not affected, it is true for yield. While, however, the removal of the yams enabled the interplanted cotton to improve its position relative to pure cotton in growth of the plant body, this extra growth did not cause a similar overtaking in flower production. Although growth of the plant body or, to be exact, node production directly limits potential flower production, the relationship between growth and actual flowering is too obscure to render any detailed

discussion profitable at this stage of the investigation. All that can be said at present is that the loss of crop due to yam competition may definitely be referred to a restriction of flower production, and that this is intimately connected with a depression of growth of the plant body.

SUMMARY.

During the season under review it has been shown that—

1. Due to intercropping the yield, boll production and flower production of cotton was depressed by about thirty *per cent.*

2. Until the cessation of the competitive effect of the yam crop, the growth of the plant body was depressed by about thirty *per cent.*; thereafter the intercropped plants achieved some measure of recovery.

3. Intercropping was without influence on the following:—

   (*a*) Shape of the plant.
   (*b*) Shedding.
   (*c*) Boll Weight.
   (*d*) Period of maximum delivery of the crop.
   (*e*) Lint Length.

4. There is some evidence that intercropping has a depressing effect on ginning percentage.

5. The competitive effect of the yam plant was confined to a radius of three feet.

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PALM OIL TESTING.

BY

W. E. DE B. DIAMOND, M.A., PH.D., AND M. GREENWOOD, M.SC.

When the Produce Inspection Scheme was started by the Department it was decided that the maximum amount of impurities allowable in palm oil should be two *per cent.*

Normally the amount of impurity present is estimated by means of the "try pan" test, which, when carried out by an experienced examiner, gives satisfactory results. This is, however, an empirical test, and it soon became evident that a more accurate method of testing was needed to deal with certain "border line" cases. After a certain amount of preliminary investigation the "centrifuge" test was introduced, the procedure being as follows:—

If beach conditions allow, the cask is rolled before being opened; otherwise the oil is well stirred with the try-rod. Three "tries" are drawn, one from the bottom, one from the middle, one from the top of the cask, the try-rod being moved upwards for about six inches during the actual drawing. The samples are thoroughly mixed in a clean vessel, and about 150 c.c. withdrawn and heated to 70°C. in an enamel jug. Keeping the oil well agitated, two balanced graduated centrifuge tubes, of 50 c.c. capacity, are filled, placed in opposite arms of the centrifuge and spun for eighty turns of the handle after the machine has reached 3,500 r.p.m.

The combined volume of dirt and water is read in each tube, and the average taken. Oils giving a reading of over 0.5 c.c. are rejected as containing impurities in excess of the two *per cent.* allowable. The factor used, therefore, for converting tube readings to weight percentage is 4.0.

Although this method of testing has been quite useful, it has not proved entirely satisfactory, and in some instances it was shown that the amounts of impurity as determined by the centrifuge test were considerably higher than those obtained by analysis in England, indicating that the conversion factor in the former method was too high. In spite of the fact that in Nigeria the centrifuge test is used to determine the total amount of impurities present, while in England the amounts of dirt and water are separately and accurately determined by standard chemical tests, these differences in procedure did not seem sufficient to account for the considerable discrepancies noted. The question therefore arose as to whether the discrepancies

were due to errors in sampling prior to testing, especially as there is a considerable change in the viscosity of the oil with the change in temperature during the period of shipment from the coast to home ports. Thus inconsistent results might be caused, in whole or in part, by inherent errors in the centrifuge test or by sampling errors prior to testing, and it was therefore decided to undertake the following programme of work :—

(i) To make a critical examination of the centrifuge test.

(ii) To ascertain the possible errors due to sampling : (*a*) in Nigeria and (*b*) in England.

PART I.

The Centrifuge Test.

From the description of the centrifuge test given above it will be noted that the volume of the impurities is first determined and then this volume is multiplied by a factor F. to determine percentage of impurity by weight. Since the impurities, water and dirt,—the latter consisting of sand and/or fibrous matter—have different specific gravities, it was necessary to determine the relation between the factor F. and the nature of the impurity.

1.—Addition of water to Pure Oil.

Varying proportions of water were added to a clean dry oil obtained by boiling a filtered oil previously cleaned in the de laval separator. Each sample was centrifuged in duplicate and the average reading taken.

TABLE I.

Test No.	Water % by weight.	Tube reading c.c. at 70C°.	Increase in % weight water.	Increase in tube reading. in c.c.	F.=Impurity-·16 T.
1.	.56	.15	—	.15	2.66
2.	1.11	.36	.55	.21	2.64
3.	1.67	.57	.56	.21	2.65
4.	2.23	.79	.56	.22	2.64
5.	2.78	1.07	.55	.28	2.45
6.	3.34	1.36	.56	.29	2.35

When a little water is added to dry oil, and the whole shaken up, a small quantity of water is absorbed by the oil and the remainder of the water forms an intimate mixture, or emulsion, with the oil. On centrifuging such an emulsion the water in the emulsion is separated from the oil and the volume is read off in the graduated part of the centrifuge tube, but the small quantity of water which is

dissolved in the oil is not separated. This is clearly seen in the table above, where the second, third, and fourth equal addition of .56 *per cent.* water give a corresponding equal increase of .21 c.c. in the tube reading but the first addition of .56 *per cent.* water only gives a tube reading of .15 c.c.

Now if 55 *per cent.* water gives an increase in the tube reading of .21 c.c. then the conversion factor is $\frac{.55}{.21} = 2.62$; and since the addition of .55 *per cent.* of water gives, on the average, within limits with which we are concerned, an increase of .21 c.c. in the tube reading, there was on the first addition of .56 *per cent.* of water an absorption of water by the oil corresponding to a tube reading of .21 − .15 = .06 c.c. This difference in the tube readings of .06 corresponds to 2.62 (.06) *per cent.* of water = .16 *per cent.* of water. From this it follows that the tube readings for the subsequent additions of water do not correspond to the total impurity present but only to the (total impurity − .16 *per cent.*) so that the conversion factor should be instead of being $\frac{\text{per cent. impurity}}{\text{tube reading}}$ $\frac{\text{per cent. impurity} - .16}{\text{tube reading}}$ This formula has been used in calculating the conversion factor F. shown in column 6 Table I.

In the 5th and 6th test it will be seen that the increase in the tube readings no longer remains constant, but increases whilst the conversion factor decreases. This is due to the fact that under the conditions of the experiment the centrifugal force available is not large enough completely to separate the water from the oil, so that there is a certain amount of emulsion as well as water in the bottom of the tube. This, however, is unimportant in the practical use of the centrifuge test, since the amount of impurity is now well over the two *per cent* allowable.

2.—Addition of Fibre to Pure Oil.

The fibrous matter found as an impurity in palm oil consists of particles of pericarp fibre. Owing to their cellular structure, such particles of fibre, when introduced into a liquid, function like a sponge, absorb some of the liquid and increase in volume. The size of the particles is largely dependent on their structure; thus the large pieces of fibre often found in commercial oils usually consist of thick walled cellular material that is not easily broken up and will not absorb much oil, whereas very fine particles of fibre usually consist of thin walled, soft and more elastic tissue that can swell up and absorb more oil than the thick walled material. Further, owing to the lower surface tension of oil as compared with water, this fibrous matter will swell up to a greater extent in oil than in water.

Thus a quantity of fibrous dirt, extracted from oils made by the Cooker Press process at Moor Plantation, had an apparent volume in oil of 1 c.c., but after extraction and drying the volume was found to be 0.2 c.c.; then, after soaking for twenty-four hours in dry oil, it again absorbed oil until it had regained its original volume. A series of oils was made up by the addition of different weights of such fibrous dirt to pure dry oil; samples of oil were then centrifuged in duplicate as in the previous experiment; the results are tabulated in Table No. II and plotted on the graph Fig. I

TABLE II.

Dirt per cent. by weight.	*Tube readings c.c. at 70° C*
0.020	0.11
0.049	0.25
0.093	0.46
0.111	0.54
0.141	0.68
0.175	0.89
0.207	1.07
0.257	1.35
0.284	1.50

It will be seen that the graph is a straight line, equal additions of fibre giving corresponding increases in the tube reading. It should be noted that under the condition of the experiment the oil absorbed by the fibre is not extracted by the centrifugal force applied.

3.—Addition of Water to Oil containing Fibre.

Varying amounts of water were added to two dry oils containing (*a*) 0.08 *per cent.* and (*b*) 0.16 *per cent.* of dirt respectively.

Series (*a*).

Per cent. by weight.					
Water	0.00	1.03	1.64	2.09	2.72
Water + dirt	0.08	1.11	1.72	2.17	2.80
Tube reading c.c.	0.40	0.35	0.58	0.72	0.95

Series (*b*).

Per cent. by weight.					
Water	0.00	0.99	1.52	2.10	2.55
Water + dirt	0.16	1.15	1.68	2.26	2.71
Tube reading c.c.	0.84	0.80	0.98	1.16	1.38

These figures are plotted on the graph Fig. I.

In series (*a*), containing .08 *per cent.* fibrous dirt, it is seen that on the addition of water the volume of the tube reading immediately decreases by .05 cc. in spite of the extra one *per cent.* impurity. This decrease in volume is due to two causes; firstly the dry oil, as in experiment I. above, absorbs some of the water and secondly the oil which was absorbed by the fibre is now replaced by water, and the volume of the fibre is considerably reduced. If this were not so, then using the factor of 2.62 from experiment I, an addition of 1.03 *per cent.* water should give a tube reading of .39 c.c., irrespective of the volume now occupied by the fibre, whereas the actual reading was .35 c.c.; so that (.39-.35) at least .04 c.c. (=.094 *per cent.* by weight) of water has been absorbed by the oil. But the oil in the fibre has now been replaced by water and the volume of the fibre reduced so that it may safely be assumed that the reduction in volume of .05 c.c. = .13 *per cent.* is wholly due to absorption of water by the dry oil. The tube reading of .35 c.c. will then correspond to an impurity of .98 *per cent.* and the factor F. will be $\frac{.98}{.35}=2.8$. The successive additions of water give corresponding increases in the tube reading, the graph is a straight line and F. remains constant at 2.8 T + .13 *per cent.* If no allowance is made for the water absorbed by the oil the factor is 3.

In series (*b*) with .16 *per cent.* of fibrous dirt there is again a decrease in volume on the addition of water which may be accounted for by absorption of this volume (.04 c.c. = .09 *per cent.* by weight of water) by the dry oil. But with a total impurity of 1.15 *per cent.* the tube reading instead of falling to about 0.4 c.c. as in series (*a*), remains at the high level of 0.80 c.c. and with successive additions of water continues to increase at this high level. This is clearly seen in the graph. The explanation of the high tube readings recorded in this experiment seems to be that the oil previously absorbed by the fibrous dirt is only partially replaced by the added water while that portion of the fibre which still contains oil occupies its original large volume. The particular conditions examined in this experiment do not, however, normally arise in commercial oils.

Having examined the effect of varying quantities of dirt and water, both separately and in certain mixtures, on the conversion factor, a number of samples of commercial oils were obtained and similarly examined. The results of some of the analyses are set out in Table No. IV below in which the total impurity, as determined by standard chemical tests, is compared with the tube readings recorded in the centrifuge test: the conversion factor F. in column 6 is calculated from $\frac{\text{total impurity}}{\text{tube reading}}$

TABLE IV.

Oil No.	Dirt % by weight.	Water % by weight.	Total Impurity.	Tube Reading c.c.	F.
886	0.39	0.55	0.94	0.19	0.95
A1	0.44	0.53	0.97	0.28	3.46
884	0.48	0.61	1.09	0.28	3.89
A4	0.63	0.46	1.09	0.29	3.76
A12	0.51	0.65	1.16	0.46	2.52
A6	0.40	0.80	1.20	0.35	3.43
883	0.54	0.78	1.32	0.35	3.77
A2	0.84	0.55	1.39	0.35	3.97
M1	0.61	0.82	1.43	0.46	3.11
A11	0.89	0.65	1.54	0.57	2.70
881	0.78	1.15	1.93	0.54	3.57
885	1.04	0.91	1.95	0.64	3.05
A7	0.67	1.43	2.10	0.86	2.44
A3	0.78	1.54	2.32	0.77	3.01

These results have been plotted on the graph Fig. II together with some other results not shown in the above table. The dirt in these oils usually consists of coarse fibre and a certain amount of sand, and after a sample has been centrifuged, three layers, viz: are sand, water and fibre, often seen at the bottom of the tube. The presence of sand tends to increase the conversion factor owing to its higher specific gravity, but coarse fibre with a small capacity for absorbing oil and water tends to decrease the factor. From the graph it will be seen that the points are fairly evenly disposed about a constant conversion factor line of 3.0.

CONCLUSION.

1. The conversion factor is dependent on the total amount and nature of the impurity in an oil.

2. Fibre alone gives a very low but constant conversion factor and, owing to its greater power of absorption, fine fibre will give a lower conversion factor than coarse fibre. If water is present alone and under two *per cent.* the percentage impurity is given by the formula 2.65 T + .16. When however water and fibre are present together the factor is normally greater than 2.65, though under certain circumstances it may be less. Sand, owing to its higher specific gravity, causes a greater increase in the factor than fibre.

3. A number of samples of commercial oils were examined and it has been shown that when the tube readings are plotted against

percentage impurity the points are fairly evenly disposed about a line corresponding to a constant conversion factor of 3.

4. The original factor of 4.0 corresponding to a two *per cent.* impurity with a tube reading of 0.5 c.c. appears to be too exacting, and it is suggested that the factor should be 3.0 with a volume of 0.6 c.c.

PART II.

Methods of Sampling.

In order to investigate the possible errors due to sampling ten casks of oil were set aside and specially marked. These casks were sampled in Nigeria and after shipment to England were again sampled at Liverpool.

The methods of sampling were as follows:—

(*a*) At Lagos.—Firstly all the casks after being rolled were sampled by the usual method adopted when a centrifuge test is to be made, three tries being taken. Secondly, five of the casks were given an equal amount of very thorough rolling, and six tries were then taken from each cask.

(*b*) At Liverpool.—A separate sample from each cask, consisting of one try, was first taken, then a second sample was taken from each cask consisting of three tries.

The analyses of both sets of samples are set out in the table below: all the oils were soft oils.

TABLE.—IMPURITIES IN PALM OIL.

Cask No.	Ibadan Tests.			Liverpool Tests.		
	Sample.	Dirt %	Water %	Sample.	Dirt %	Water %
290	3 trys ...	·50	1·03	1 try ...	·05	·56
	6 „ ...	·44	·87	3 trys ...	·07	·49
291	3 „ ...	·26	·65	1 try ...	·06	·30
	6 „ ...	·27	1·05	3 trys ...	·05	·27
292	3 „ ...	·39	1·09	1 try ...	·06	·35
	6 „ ...	·54	1·05	3 trys ...	·04	·26
14	3 „ ...	·44	1·14	1 try ...	·11	·58
	6 „ ...	·52	1·06	3 trys ...	·10	1·20
15	3 „ ...	·41	·61	1 try ...	·06	·25
	6 „ ...	·50	·50	3 trys ...	·10	·30
16	3 „ ...	·31	·51	1 try ...	·13	·24
				3 trys ...	·04	·26
21	3 „ ...	·38	·87	1 try ...	·05	·22
				3 trys ...	·04	·37
22	3 „ ...	·43	·58	1 try ...	·10	·36
				3 trys ...	·12	1·60
25	3 „ ...	·45	1·00	1 try ...	·06	·23
				3 trys ...	·07	·24
26	3 „ ...	·49	·93	1 try ...	·15	·33
				3 trys ...	·06	·34

It will be seen from the above figures that the differences due to the two different methods of sampling as carried out at each centre are of about the same order: that is to say the three try method at Lagos gives results reasonably consistent with those obtained by taking six trys, and at Liverpool the results from the one try sample are reasonably consistent with those from the three try sample. In the latter set of figures, however, there are two big differences in the samples from casks Nos. 14 and 22 due to pockets of water.

The difference between the total percentage impurities as determined in Nigeria and in England are wide, the Liverpool figures being very much lower.

Since the results obtained by the two methods of sampling at Liverpool are reasonably consistent, it does not seem that the increased viscosity of the oil can account for the anomalous results. It is thought that the greater part of the difference is due to the fact that the impurities sink to the bottom of the cask during the voyage and form a sludge which adheres to the sides of the cask. This sludge does not subsequently become remixed with the rest of the oil, so that the oil appears to undergo a further process of purification, by sedimentation, during the voyage, resulting in a cleaner sample being obtained at Liverpool than on the coast.

It seems unlikely, therefore, that any modification of methods of sampling either on the coast or at home would entirely overcome the discrepancies between the home and coast tests. In support of this contention it may be stated that the sides of some recently emptied casks examined in Nigeria were coated with a sludge; while a tank which had just been emptied and in which oil had been shipped in bulk was examined at Liverpool and it was seen that there was a certain amount of sludge at the bottom.

The authors wish to thank the Superintending Inspector of Produce, and Messrs. Miller Brothers for supplying the samples of commercial oils examined.

ANNUAL REPORT, MOOR PLANTATION, IBADAN, 1928.

This plantation was in charge of Mr. H. G. Poynter from 1st January to 30th April, 1928.

Mr. D. H. Brown was in charge for the remainder of the year.

The field experimental work on annual crops for the year 1928 has been mainly the continuation of trials already in progress. Various rotation experiments covering an area of ninety-eight acres form an important part of this work. None of these rotations were in existence prior to 1922, and, until they have been continued for several more years, reliable deductions are not possible. Figures for the four year rotations showing yields and labour over a period of six years are interesting and have been included in this report.

The results of important experiments dealing with the methods of treatment of green manures are summarised as in previous bulletins.

Artificial fertilisers have been tried on late maize, and the investigations are to be continued.

The total rainfall recorded for the year was 45·11 inches,—4·36 inches less than the average of a nineteen years period. The feature of the distribution was an abnormally high fall during May and a lack of rain in June. Despite this, conditions were very favourable for growth and harvesting. The result has been that the general yield for all crops except yams has been above the average. Groundnuts grown on the main rotation block gave a yield higher than any previously recorded on the farm. The cotton crop was good and remarkably healthy. The yam crop was very disappointing. It is probable that the failure may be ascribed to the following causes :—

(*a*) Planting was done in January and at the beginning of February, which is contrary to native practice.

(*b*) The grass mulch was not sufficiently thick especially for yams planted at this time.

Cover Crop Experiment, 1928. Table No. 1.

	Yield of early maize in lb. dry grain per acre.	Odds that difference is significant.
Average yield of 10 plots following Dolichos	1,337	
Average difference of 2 plots following Canavalia	−285±162	24 : 1
Average difference of 2 plots following Mucuna	− 83±162	2 : 1
Average difference of 2 plots following Cowpeas	− 59±162	2 : 1
Average difference of 1 plot following Dolichos (dug in December 1st) ...	− 98±227	2 : 1
Average difference of 1 plot following weeds (not cultivated prior to ridging.	+133±227	2 : 1
Average difference of 1 plot following weeds (buried December 1st and cut January 1st)	−345±227	14 : 1

The results of this trial over a period of five years indicate clearly that on the control plots fertility is being maintained, and that the yield of maize following Dolichos has been on the average better than that after any of the other cover crops, or than that after weeds despite the fact that Mucuna was reported as providing the best cover throughout the season, and that one weed plot has this season given an exceptional yield. Maize after Canavalia has declined year by year. The effect of Cowpeas as a cover crop is greatly diminished owing to the difficulty of obtaining a good stand. The influence of Mucuna on the succeeding crop has been a steady one; it is easy to establish, grows vigorously and covers the land quickly and thoroughly. The saving in weeding costs on account of this more than compensates for the slightly lower yield when compared with Dolichos.

Green Manuring Experiment, 1928. Table No. 2.

	Yield of late maize in lb. dry grain per acre.	Odds that difference is significant.
Average yield of 7 plots following Mucuna	1,608	
Average difference of 2 plots following Dolichos	−174±82	55 : 1
Average difference of 2 plots following Canavalia	−237±82	534 : 1
Average difference of 2 plots following Cowpeas	−104±82	9 : 1

As in the cover crop experiment the yield following Canavalia has fallen off year by year and this crop has proved entirely unsatisfactory for use as green manure. Cowpeas have not given good results. Dolichos, except in 1928 when the stand of this

crop was very inferior, has given satisfactory results so far as the yield of the succeeding crop has been concerned ; the land however has been poorly covered and a great deal more weeding has therefore been necessary than there has been in the case of Mucuna. The high yield of the Mucuna plots as compared with that of previous years is an indication that the level of fertility is being more than maintained on this block.

DRY SEASON TREATMENT OF COVER CROP EXPERIMENT. TABLE NO. 3.

	Yield of late maize in lb. dry grain per acre.	Odds that difference is significant.
Average yield of 9 plots dug in at beginning of the dry season 26th October, 1927	1,903	—
Average difference of 8 plots dug in at the end of the dry season, 24th February, 1928	− 86 ± 50	21 : 1

The results obtained in 1926 and 1927 were confirmed this year, indicating that a slightly larger yield of maize follows a cover crop buried at the beginning of the dry season than that following a cover crop left to stand during the dry period and buried in February. This difference is so small that the date of ridging in the cover crop may be dependent on the labour and other conditions prevailing at the time. The ridging can be done more efficiently if it is undertaken before the land becomes too hard at the beginning of the dry season, but this has the slight disadvantage that additional weeding is necessary later.

TREATMENT OF COVER CROP EXPERIMENT, 1928. TABLE NO. 4.

(A)	Yield of early maize in lb. dry grain per acre.	Odds that difference is significant.
Average yield of 5 plots burnt in February and ridged	1,622	—
Average difference of 4 plots burnt in February and moulded	−105 ± 47	71 : 1

The ridged plots in 1928 have given the best yield contrary to the results obtained in each of the two previous years. This seems to show that thorough deep cultivation in the form of ridging is required though not necessarily every year. A comparison of costs is included with the Table at the end of the report.

(B)	Yield of early maize in lb. of dry grain per acre.	Odds that difference is significant.
Average of 5 plots cut in November and ridged at once	1,908	—
Average difference of 4 plots cut in November and ridged in February ...	−102 ± 112	5 : 1

Ridging at the beginning of the dry season gave better results than ridging at the end, in accordance with previous findings, and also with the dry season treatment of cover crop experiment mentioned above. It should be noted however that whereas in the latter experiment the cover crop was left standing during the dry season on the later ridged plots, in this experiment it was cut in November.

Comparing treatments (A) and (B) during the last three years it is evident that burning the cover crop is not a good practice.

Manurial Experiment, 1928.

Cropping. A3N. Yams and Late Maize.
A3S. Yams and Mucuna.

Table No. 5.

A3N.	Gross yield of tubers in lb. per acre.	Odds that difference is significant.
Average yield of 7 unmanured plots ...	9,046	—
Average difference on 2 plots manured with Nitrogen	+887±801	6 : 1
Average difference on 2 plots manured with Phosphates	−763±801	5 : 1
Average difference on 2 plots manured with Nitrogen and Phosphates ...	+961±801	8 : 1

Table No. 6.

	Yield of late maize in lb. per acre.	Odds that difference is significant.
Average yield of 7 unmanured plots ...	466	—
Average difference on 2 plots manured with Nitrogen	+ 215 ± 64	3,029 : 1
Average difference on 2 plots manured with Phosphates	— 22 ± 64	—
Average difference on 2 plots manured with Phosphates and Nitrogen ...	+ 216 ± 64	3,029 : 1

Table No. 7.

A3S.	Gross yield of tubers in lb. per acre.	Odds that difference is significant.
Average yield of 7 unmanured plots ...	9,637	—
Average difference on 2 plots manured with Nitrogen	— 46 ± 1,388	—
Average difference on 2 plots manured with Phosphates	+ 297 ± 1,388	—
Average difference on 2 plots manured with Nitrogen and Phosphates ...	− 747 ± 1,388	2 : 1

As in previous years on the northern portion the addition of nitrogen in the form of thirteen cwt. cotton seed per acre had the effect of increasing the yield whereas finely ground phosphatic rock, ten cwt. per acre, had a depressing effect. In combination the increase in the yield is similar to the effect of nitrogen alone. The northern portion, under crops for seven years without any green manuring, is now in a poor state of fertility the control plots of late maize giving as low a yield as 466 lb. per acre. The southern half of the rotation includes a green manure or cover crop in two out of every three years. The standard error was so great in A38. as to render the difference in the yield of yams from the manured and unmanured plots insignificant.

Late Maize Spacing Experiment, 1928. Table No. 8.

	Yield of maize in lb. dry grain per acre.	Odds that difference is significant.
Average yield of 10 plots with stands 18″ apart	476	—
Average difference of 5 plots with stands 12″ apart...	— 82 ± 55	14 : 1
Average difference of 4 plots with stands 24″ apart...	+ 80 ± 62	9 : 1

The general state of the fertility of this block is low and the soil throughout is far from uniform. The crop of late maize following one of early maize was a poor one and varied considerably from plot to plot. Though it is not wise to attach too much importance to the above figures, wide spacing proved best for poor soil. Experience teaches that it is not economical to attempt to grow an early and a late maize crop from the same land in the one season.

Fertiliser Trial, 1928. Table No. 9.

	Yield of late maize in lb. dry grain per acre.	Odds that difference is significant.
Average yield of 32 unmanured plots ...	1,484	—
Average difference on 4 plots manured with Nitrogen	+ 280 ± 145	34 : 1
Average difference on 4 plots manured with Phosphates	+ 134 ± 145	5 : 1
Average difference on 4 plots manured with Potash	+ 68 ± 145	2 : 1
Average difference on 4 plots manured with Nitrogen and Phosphates ...	+ 267 ± 145	27 : 1
Average difference on 4 plots manured with Potash and Phosphates	— 86 ± 145	3 : 1
Average difference on 4 plots mannred with Nitrogen and Potash	+ 255 ± 145	24 : 1
Average difference on 4 plots manured with Nitrogen, Phosphates and Potash	+ 321 ± 145	71 : 1

For the first time a trial was carried out on a late maize crop with the following artificial fertilisers :—

Sulphate of Ammonia ...	... 1 cwt. per acre.
Muriate of Potash ...	... ½ " " "
Super-phosphate ...	... 3 " " "

These were tested alone and in combination against control plots receiving no manure. The plots were $\frac{1}{10}$th of an acre each, and, having been out of cultivation for two years, had reverted to "bush". The potash and phosphates were broadcasted immediately before ridging while the nitrogen was applied as a top-dressing to the upper part of the ridges three weeks after planting. The effect of nitrogen appears to be roughly equivalent to an increase of 250 lb. of grain per acre.

The figures relating to phosphates and potash alone and in combination are not convincing. The yields from the plots receiving manure are comparable with the yields following Mucuna in the Green Manuring Experiment.

TRIAL OF CALCIUM CYANAMIDE, TABLE No. 10.

	Yield of late maize in lb. per acre.	Odds that difference is significant.
Average yield of 6 unmanured plots ...	2,254	—
Average difference on 4 plots manured Calcium Cyanamide	+ 235 ± 428	3 : 1

A small scale trial of Calcium Cyanamide applied as a top dressing (2 cwt. per acre) to a crop of late maize three weeks after planting was carried out. The plots were each 0·09 acre, four being under treatment. The average yield of the control plots was very high, due no doubt to the land being newly under cultivation from bush. No marked difference could be seen during the growing season.

GROUNDNUTS, 1928. "RIDGING" *versus* "MOULDING".

TABLE No. 11.

	Yield dry unshelled nuts lb. per acre.	Odds that difference is significant.
Average yield of 10 plots ridged ...	1,657	—
Average difference on 9 plots moulded ...	+ 70 ± 81	4 : 1

The groundnuts followed a crop of cotton on one of the main rotation blocks. During the first two months the plants on the ridged plots grew better but later on in June there was no apparent differences between the two. A few plants were attacked by a sclerotium disease and had to be uprooted and burnt.

The yields from the moulded and ridged plots were to all intents and purposes alike. The saving in labour costs in favour of moulding was equivalent to twenty-two man days per acre which is approximately the value of two and a half cwt. groundnuts.

"Hoeing" versus "Hand-weeding". Table No. 12.

	Yield dry unshelled nuts lb. per acre.	Odds that difference is significant.
Average yield of 10 plots hoe-weeded weekly	1,929	—
Average difference of 9 plots hand-weeded as required	− 620 ± 63	∝ : 1

Here too the previous crop was cotton and the groundnuts were grown on moulded land. The odd plots were hoe-weeded weekly until the size of the plants made this impossible and the even plots hand-weeded as necessary throughout the season. Each operation was carried out eight times, the difference in cost being equivalent to fifteen man days per acre in favour of hoe-weeding. Apart from the saving in labour the figures show a considerably increased yield favouring hoe-weeding.

Cotton Variety Test. "Meko" *versus* "Ishan". Table No. 13.

	Yield of seed cotton lb. per acre.	Odds that difference is significant.
Average yield of 20 plots Meko	295	—
.. difference of 6 plots Ishan "A"	+ 336 ± 31	∝ : 1
.. .. 6 „ „ "B"	+ 53 ± 31	21 : 1
.. .. 6 „ „ "H"	− 34 ± 31	6 : 1

The selected Ishan strain "A" cotton gave an increased yield which is significant when compared with Meko cotton. The yield of 631 lb. per acre is above the average for the farm. This block had not the healthy appearance of the remainder of the cotton on the plantation this year owing to jassid infection which affected particularly the Meko cotton. The yields of the Ishan cotton plots in between the Meko plots may have suffered unduly because of this. Selected Ishan strain "A" appears superior to both "B" and "H" from the point of view of yield.

Four year Rotations.

This trial is carried out on a block of twenty acres divided into forty half acre plots. Each rotation is duplicated. Intensity of cropping consistent with maintenance of fertility is the basis of the experiment.

In the initial stages of an experiment such as this no definite conclusions can be drawn. There are many factors besides seasonal variations to be considered. It should be noted that prior to 1926 Allen cotton was planted throughout since then Ishan has been grown. Lagos White maize has now taken the place of Creole and Natal maize. Mucuna has replaced Dolichos.

The yield figures from the maize crops are probably the most reliable indications of the state of fertility. Cotton is extremely susceptible to seasonal variations, as evidence the complete failure of the 1927–28 crop.

Yields are expressed as follows :—

Cotton.—as seed-cotton, lb. per acre.
Maize.—as dry grain, lb. per acre.
Yams.—as gross yield of tubers, lb. per acre.
Groundnuts.—as dry undercorticated nuts, lb. per acre.

Four Year Rotations.

Yields per acre.

	1923–24.	1924–25.	1925–26.	1926–27.	1927–28.	1928–29.
Rotation 1.						
A. Mucuna	354	216	316	608	53	763
Cotton						
B. Mucuna	1,170	1,014	415	1,342	1,354	1,719
Late Maize						
C. Groundnuts	917	556	480	1,126	809	1,371
Mucuna						
D. Yams	6,513	8,458	2,032	6,174	5,721	4,362
Mucuna						
Rotation 2.						
A. Mucuna	399	198	317	636	50	638
Cotton						
B. Early Maize	1,787	2,007	2,090	2,249	1,163	2,356
Mucuna						
C. Groundnuts	859	518	213	1,274	722	1,289
Mucuna						
D. Yams	5,410	8,243	2,452	6,464	6,799	4,387
Mucuna						
Rotation 3.						
A. Mucuna	358	231	322	749	58	727
Cotton						
B. Groundnuts	971	420	266	999	149	1,161
Mucuna						
C. Early Maize	2,067	2,531	2,697	1,768	1,445	2,255
Late Maize	486*	69*	failed.	871	1,105	1,372
D. Yams	6,988	8,392	2,317	4,656	5,969	3,474
Mucuna						
Rotation 4.						
A. Groundnuts	1,001	867	285	1,374	798	1,262
Cotton	376	250	132	411	58	578
B. Early Maize	2,046	1,965	2,062	2,124	977	1,096†
Late Maize	483*	44*	failed.	892	1,126	1,647
C. Groundnuts	865	553	552	1,128	892	1,265
Mucuna						
D. Yams	7,899	9,344	2,094	6,686	5,862	3,355
Mucuna						
Rotation 5.						
A. Groundnuts	911	1,050	193	1,568	760	1,291
Cotton	357	255	134	538	51	564
B. Maize	1,778	1,950	2,322	2,300	1,016	2,210
Cowpeas						
C. Early Maize	2,337	2,497	2,974	1,729	1,678	2,072
Late Maize	547*	77*	failed.	764	1,090	1,114
D. Yams	7,236	8,425	2,510	5,016	5,964	3,639
Mucuna						

* Guinea-corn.

† Groundnuts.

Coconuts (Table No. 14).

As in previous years the difference in yield between the two plots is considerable and in favour of the wider spacing. The crop on each block is less than half that of last season. This may be due to theft.

Liberian Coffee, 1928.

Experiments on fermentation were carried out. It is found that a longer period than twenty-four hours is undesirable.

Cocoa (Table No. 15).

An average of 303 lb. per acre of dry beans may be considered as only a fair yield. Disease of the pods was noticed at the commencement of the season but disappeared as drier weather set in.

Kola (Table No. 16).

The two and a half acre plot of Gbanja Kola gave a very poor yield, many of the pods were malformed and contained inferior nuts. It is probable that the present spacing is too close. Recorded yields are as follows, but these are almost certainly greatly reduced by theft, so that they are unreliable even for purposes of comparison.

	Yield of good nuts, lb. per acre.
1923	80
1924	114
1925	349
1926	466
1927	109
1928	88

Distribution of Plants.

The following were distributed :—

Coconut palms	44
Kola plants	251
Cocoa	11
Coffee	1,225
Oil Palms	2
Fruit trees	4,502
Ornamental plants ...	4,927

Poultry.

606 eggs for hatching were disposed of and twelve male birds sold.

Rainfall, 1928.

Moor Plantation, Ibadan.

Month.	Rainfall in inches.	Average rainfall for a period of nineteen years. 1910–1928.
January	0·54	0·37
February	0·78	0·78
March	1·50	3·42
April	4·93	5·88
May	10·03	6·16
June	2·25	7·21
July	6·83	6·49
August	2·56	3·38
September	6·83	7·21
October	6·94	6·46
November	1·08	1·94
December	0·84	0·17
Total	45·11	49·47

TABLE No. 1.

Cover Crop Experiment—1928.

Plot.	Late Season Treatment.	Crop, 1928.	Yield of Maize dry grain lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block YI. S.				
1	Dolichos	Early Maize	1,182	
2	Canavalia	„	1,034	− 299
3	Dolichos	„	1,484	
4	Mucuna	„	1,222	− 96
5	Dolichos	„	1,151	
6	Cowpeas	„	1,153	− 37
7	Dolichos	„	1,228	
8	Canavalia	„	900	− 270
9	Dolichos	„	1,112	
10	Mucuna	„	1,140	− 69
11	Dolichos	„	1,306	
12	Cowpeas	„	1,268	− 80
13	Dolichos	„	1,390	
14	Dolichos dug in December 1st	„	1,456	− 98
15	Dolichos	„	1,718	
16	Weeds (not cultivated) prior to ridging ...	„	1,701	+ 133
17	Dolichos	„	1,418	
18	Weeds buried December 1st and cut January 1st ...	„	1,056	− 345
19	Dolichos	„	1,384	
20	Dolichos	„	(1,646)	Non-experimental.
	Average		1,337	

Average yield of 10 plots following			Dolichos	...	1,337 lb. per acre.
(*a*) difference	„ 2	„	Canavalia	...	−285±162
(*b*)	„ „ 2	„	Mucuna	...	− 83±162
(*c*)	„ „ 2	„	Cowpeas	...	− 58±162
(*d*)	„ „ 1	„	Dolichos dug December 1st	...	− 98±227
(*e*)	„ „ 1	„	Weeds	...	−133±227
(*f*)	„ „ 1	„	Weeds buried Dec. 1st and cut January 1st	...	−345±227

Maize.

Variety—Lagos White.

Ridged January 21st to 24th ; Sown April 7th ; Supplied April 19th and May 17th.

Weeded, April 24th. May 15th and 16th. Harvested August 9th.

Ridges 6′ stands 18″ apart on each side of the ridge, 1 plant per stand.

Plot 0·18 acres each.

Root—mean—square—difference between neighbouring control plots = 227 lb. per acre.

Beans Planted June 25th, 1927.

TABLE No. 2.

Green Manuring Experiment 1928.

Plot.	Early Season Treatment.	Crop.	Yield of Maize in lb. dry grain per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block B3E.				
1	Mucuna	Late Maize	1,872	
2	Dolichos ...	„	1,632	−206
3	Mucuna	„	1,804	
4	Canavalia ...	„	1,380	−318
5	Mucuna	„	1,592	
6	Cowpeas ...	„	1,548	— 64
7	Mucuna	„	1,632	
8	Dolichos ...	„	1,456	−142
9	Mucuna	„	1,564	
10	Canavalia ...	„	1,336	−156
11	Mucuna	„	1,420	
12	Cowpeas ...	„	1,252	−144
13	Mucuna	„	1,372	

Maize.

Average yield of 7 plots following Mucuna ... ... 1,608 lb. per acre.
„ difference of 2 plots following Dolichos ... ±174±82 „ „
„ „ „ „ Canavalia .. −237±82 „ „
„ „ „ „ Cowpeas ... −104±82 „ „

Root—mean square—difference between neighbouring controls 115 lb. per acre.

Each plot $\frac{1}{4}$ acre, ridges 6′ apart, stands 18″ apart on each side of the ridge, 1 plant per stand.

Maize Variety—Lagos White.

Ridged	August 20th.
Planted	September 3rd.
Supplied	September 10th and 24th.
Weeded	September 20th.
Moulded	October 9th and 24th.
Harvested	December 29th.

Germination percentages of Maize after Mucuna 96 per cent.
Cowpeas 98 „
Canavalia 99 „
Dolichos 95 „

Beans. Planted March 30th, 1928.

TABLE No. 3.

Dry Season Treatment of Cover Crop, 1928.

Plot.	Late Season Treatment.	Crop.	Yield in lb. dry grain per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block B7, 8.				
1	Cover Crop dug in October ...	Maize	1,764	
2	Cover Crop dug in February	,,	1,972	+ 50
3	Cover Crop dug in October ...	,,	2,080	
4	Cover Crop dug in February	,,	2,004	− 14
5	Cover Crop dug in October ...	,,	1,956	
6	Cover Crop dug in February	,,	1,712	− 200
7	Cover Crop dug in October ...	,,	1,868	
8	Cover Crop dug in February	,,	1,824	− 36
9	Cover Crop dug in October ...	,,	1,852	
10	Cover Crop dug in February	,,	1,816	− 10
11	Cover Crop dug in October ...	,,	1,800	
12	Cover Crop dug in February	,,	1,680	− 124
13	Cover Crop dug in October ...	,,	1,808	
14	Cover Crop dug in February	,,	1,564	− 326
15	Cover Crop dug in October ...	,,	1,972	
16	Cover Crop dug in February	,,	1,968	− 30
17	Cover Crop dug in October ...	,,	2,024	
	Average		1,903	− 86

Average yield of 9 plots dug in at beginning of dry season 1,903 lb. per acre.

,, difference of 8 plots dug in at end of ,, ,, − 86 ± 50 lb. per acre.

Variety—Lagos White. Cover Crop Mucuna.

Ridged October 26th and February 24th—Planted April 4th—Supplied 19th.

April and 16th May—Weeded April 12th, 27th and May 10th—Harvested August 2nd.

Plots—$\frac{1}{4}$ acre each. Ridges 6′ apart stands 18″ apart on each side of the ridge. 1 plant per stand.

Root—mean—square—difference between neighbouring control plots 139 lb. per acre.

TABLE No. 4.

TREATMENT OF COVER CROP EXPERIMENT, 1928.

Plot.	Late Season Treatment.	Crop.	Yield in lb. dry grain per acre.	Increase (+) or Decrease (−) compared with mean of adjacent controls.
C5N. (A)				
1	Cover Crop cut February, ridged February	Maize	(1,584)	(Not Experimental.)
2	Burnt January, ridged February	,,	1,568	
3	Burnt January, moulded February	,,	1,492	− 34
4	Burnt January, ridged February	,,	1,484	
5	Burnt January, moulded February	,,	1,452	− 108
6	Burnt January, ridged February	,,	1,636	
7	Burnt January, moulded February	,,	1,492	− 170
8	Burnt January, ridged February	,,	1,688	
9	Burnt January, moulded February	,,	1,604	− 108
10	Burnt January, ridged February	,,	1,736	
	Average		1,622	− 105
(B)				
11	Cover crop cut November ridged February	Maize	1,864	
12	Cover crop cut November ridged February	,,	1,884	+ 52
13	Cover crop cut November ridged February	,,	1,800	
14	Cover crop cut November ridged February	,,	1,828	− 82
15	Cover crop cut November ridged February	,,	2,020	
16	Cover crop cut November ridged February	,,	1,708	−192
17	Cover crop cut November ridged February	,,	1,780	
18	Cover crop cut November ridged February	,,	1,744	−184
19	Cover crop cut November ridged February	,,	2,076	
20	Cover crop burnt February ridged February	,,	(1,872)	(Not Experimental)
	Average		1,908	−102

(A) Average yield of five plots ridged 1,622 lb. per acre.
,, difference of four plots moulded −105 ± 47 lb. per acre.

Root—mean -square—difference between neighbouring controls = 94 lb per acre.

(B) Average yield of five plots ridged in November 1,908 lb. per acre.
,, difference of four plots ridged in February −102 ± 112 lb. per acre.

Root—mean—square—difference between neighbouring controls = 223 lb. per acre.

Variety—Lagos White—Cover crop—Mucuna.

Ridged November 10th and February 22nd; Planted April 5th; Supplied April 19th, May 16th; Weeded April 24th, May 11th, 25th; Harvested August, 3rd.

Plots ¼ acre each. Ridges 6′ apart stands 18′ apart on each side of the ridge, 1 plant per stand.

TABLE No. 4—*continued.*

Comparison of costs Moulding v. Ridging (A).

Cost per acre of ridging including burning of cover crop	= 25 man days
,, ,, ,, ,, moulding ,, ,, ,, ,, ,, ...	= 12 ,, ,,
Saving in labour due to moulding	= 13 ,, ,,
Decrease in gross return due to moulding (105 lb. grain @ 3s. per cwt.) ...	= 3 ,, ,,
Nett increase profit per acre due to moulding	= 10 ,, ,,

TABLE No. 5.

MANURIAL EXPERIMENT, 1928.

Plot.	Treatment.	Crop.	Yield per acre. lb.		Increase (+) or decrease (−) compared with mean of adjacent controls.
A3N 1	No Manure	Yams	8,212		
2	N_2	,,		10,912	+ 1,706
3	No Manure	,,	10,200		
4	P_2O_5	,,		7,628	− 1,694
5	No Manure	,,	8,444		
6	$N_2 + P_2O_5$ ...	,,		8,572	+ 110
7	No Manure	,,	8,480		
8	N_2	,,		8,792	+ 68
9	No Manure	,,	8,968		
10	P_2O_5	,,		9,392	+ 168
11	No Manure	,,	9,480		
12	$N_2 + P_2O_5$ ...	,,		10,320	+ 1,812
13	No Manure	,,	9,536		
	Average		9,046		

Root—mean—square—difference between neighbouring controls 1,121 lb. per acre.

Average yield of 7 unmanured plots = 9,046 lb. per acre.

,, difference of 2 plots manured with nitrogen + 887 801 lb. per acre.

,, ,, ,, 2 plots manured with phosphates — 763 ± 801 lb. per acre.

,, ,, ,, 2 plots manured with nitrogen and phosphates + 961 ± 801 lb. per acre.

(Nitrogen = 13 cwt. cotton seed per acre. Phosphates = 10 cwt. ground rock phosphate per acre.)

Variety	—	Iyawo.
Ridged	—	December 21st.
Planted	—	January 11th.
Mulched	—	January 12th.
Staked	—	March 12th, onwards.
Weeded	—	March 31st, April 21st, May 19th, June 14th, July 21st, and August 31st.
Harvested	—	November 15th.

Each plot $\frac{1}{4}$ acre.

Ridges 6′ apart Yam sets 20″ apart.

Germination 78%.

TABLE No. 6.

MANURIAL EXPERIMENT, 1928.

Plot.	Treatment.	Crop.	Yield in lb. dry grain per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
A3N 1	No Manure	Late Maize	432		
2	N_2 ...	,,		648	+ 214
3	No Manure	,,	436		
4	P_2O_5 ...	,,		360	− 54
5	No Manure	,,	392		
6	$N_2+P_2O_5$ ...	,,		744	+ 260
7	No Manure	,,	576		
8	N_2 ...	,,		736	+ 216
9	No Manure	,,	464		
10	P_2O_5 ...	,,		484	+ 10
11	No Manure	,,	484		
12	$N_2+P_2O_5$ ...	,,		652	+ 172
13	No Manure	,,	476		

Root—mean—square—difference between neighbouring controls 90 lb. per acre.

Average yield of 7 unmanured plots ... ... 466 lb. per acre.

,, difference on 2 plots manured with Nitrogen ... +215±64 lb. per acre.

,, ,, ,, 2 ,, ,, ,, Phosphates ... − 22±64 ,, ,, ,,

,, ,, ,, 2 ,, ,, ,, Phosphates + Nitrogen +216±64 ,, ,, ,,

The manures were applied to the preceding yam crop at the following rates:—

Nitrogen ... 13 cwt. cotton seed per acre.

Phosphates ... 10 cwt. ground rock phosphates per acre.

MAIZE VARIETY ... LAGOS WHITE.

Planted ... September 3rd.

Supplied ... ,, 10th and 24th.

Weeded ... ,, 20th, October 10th.

Moulded ... October 26th and November 17th.

Harvested ... January 5th.

Ridges 6' apart standa 18" apart on each side of the ridge, 1 plant per stand.

TABLE No. 7.

MANURIAL EXPERIMENT, 1928.

Plots.		Treatment.	Crop.	Yield per acre lb.		Increase (+) or decrease (−) compared with mean of adjacent controls.
A3S	14	No Manure	Yams	7,920		
	15	N_2 ...	„		10,008	+ 710
	16	No Manure	„	10,676		
	17	P_2O_5 ...	„		9,648	− 894
	18	No Manure	„	10,408		
	19	$N_2+P_2O_5$ ...	„		9,368	− 972
	20	No Manure	„	10,272		
	21	N_2 ...	„		8,652	− 802
	22	No Manure	„	8,636		
	23	P_2O_5 ...	„		10,672	+ 1,488
	24	No Manure	„	9,732		
	25	$N_2+P_2O_5$ ...	„		9,256	− 522
	26	No Manure	„	9,816		
		Average		9,637		

Root—mean—square—difference between neighbouring controls 1,388 lb. per acre.

Average yield of 7 unmanured plots 9,637 lb. per acre.

„ difference on 2 plots manured with nitrogen ... ... − 46±1,388 lb. per acre.

„ „ „ 2 „ „ „ phosphates ... +297±1,388 „ „ „

„ „ „ 2 „ manure nitrogen + phosphates −747±1,388 „ „ „

(Nitrogen 13 cwt. cotton seed per acre. Phosphates 10 cwt. ground phosphatic rock per acre.)

Variety ... ... Iyawo.

Ridged ... ... December 21st.

Planted ... ... January 11th.

Mulched ... ... „ 12th.

Staked ... ... March 12th onwards.

Weeded ... ... „ 31st, April 21st, May 19th, June 14th, July 21st, and August 31st.

Harvested ... November 20th.

Each plot ¼ acre.

Ridges 6′ apart Yam sets 20″ apart.

Germination 77%

TABLE No. 8.

Late Maize Spacing Test, 1928.

Plot.		Distance apart.		Crop.	Yield in lb. dry grain per acre		Increase (+) or decrease (−) compared with mean of adjacent controls.
C3W	1	18′		Late Maize.	416		
	2		12″	„		368	− 62
	3	18″		„	444		
	4		24″	„		448	+ 22
	5	18″		„	408		
	6		12″	„		364	− 132
	7	18″		„	584		
	8		24″	„		764	+ 110
	9	18″		„	724		
	10		12″	„		516	− 126
	11	18″		„	560		
	12		24″	„		640	+ 94
	13	18″		„	532		
	14		12″	„		400	− 136
	15	18″		„	540		
	16		24″	„		516	+ 94
	17	18″		„	304		
	18		12″	„		324	+ 48
	19	18″		„	248		
	20	18″		„	(336)	Non	Experimental.

Root—mean—square—difference between neighbouring controls 124 lb. per acre.

Average yield of 10 plots planted at 18″ 476 lb. per acre.

„ difference 5 „ „ 12″ − 82±55 lb. per acre.

„ „ 4 „ „ 24″ + 80±62 „ „ „

Variety	...	Lagos White.
Moulded	... ...	August 31st.
Planted	... ...	September 12th.
Supplied	... ...	„ 25th.
Singled	... ...	October 1st.
Weeded	... ...	„ 12th and 24th.
Harvested	... ...	January 4th.

¼ acre plots. 6′ ridges. Stands 18″ apart on each side of ridge, 1 plant per stand.

TABLE No. 9.

Fertiliser Trial 1928.

Plot.		Treatment.	Crop.	Yield in lbs. of dry grain per acre.	Increase (+) or decrease (−) compared with mean of adjacent control.
B4.	1	No Manure	Maize.	1,368	
	2	$N_2+P_2O_5$	,,	1,566	+ 285
	3	,, ,,	,,	1,194	
	4	$N_2+P_2O_5+K_2O$	,,	1,782	+ 426
	5	,, ,,	,,	1,518	
	6	N_2+K_2O	,,	1,896	+ 288
	7	,, ,,	,,	1,698	
	8	$P_2O_5+K_2O$	,,	1,512	− 171
	9	,, ,,	,,	1,668	
C4.	1	,, ,,	,,	1,956	
	2	N_2	,,	2,226	+ 231
	3	,, ,,	,,	2,034	
	4	P_2O_5	,,	2,190	+ 279
	5	,, ,,	,,	1,788	
	6	K_2O	,,	1,818	− 18
	7	,, ,,	,,	1,884	
	8	$N_2+P_2O_5$	,,	2,238	+ 309
	9	,, ,,	,,	1,974	
	10	$K_2O+P_2O_5$	,,	1,836	− 90
	11	,, ,,	,,	1,878	
	12	N_2+K_2O	,,	1,854	+ 225
	13	,, ,,	,,	1,380	
	14	$N_2+P_2O_5+K_2O$	,,	1,578	+ 336
	15	,, ,,	,,	1,104	
	16	K_2O	,,	936	+ 186
	17	,, ,,	,,	396	
	18	,, ,,	,,	2,034	
	19	$N_2+P_2O_5$	,,	2,106	+ 201
	20	,, ,,	,,	1,776	
	21	$N_2+P_2O_5+K_2O$	,,	2,208	+ 423
	22	,, ,,	,,	1,794	
	23	N_2	,,	2,178	+ 384
	24	,, ,,	,,	1,794	
	25	P_2O_5	,,	1,878	+ 132
	26	,, ,,	,,	1,698	
	27	K_2O	,,	1,938	+ 120
	28	,, ,,	,,	1,938	
	29	$N_2+P_2O_5$	,,	1,854	+ 189
	30	,, ,,	,,	1,392	
	31	K_2O+P_2O	,,	1,266	+ 123
	32	,, ,,	,,	894	
	33	N_2	,,	1,248	+ 420

TABLE No. 9—*continued.*

C4. 34	No Manure		Maize	762		
35	" "		"	1,158		
36		N_2+P_2O	"		1,500	+ 285
37	" "		"	1,272		
38		$K_2O+P_2O_5$	"		1,038	− 204
39	" "		"	1,212		
40		N_2+K_2O	"		1,626	+ 306
41	" "		"	1,428		
42		$N_2+P_2O_5+K_2O$	"		1,698	+ 99
43	" "		"	1,770		
44		N_2	"		1,794	+ 84
45	" "		"	1,650		
46		P_2O_5	"		1,746	+ 336
47	" "		"	1,170		
48		K_2O	"		1,140	− 18
49	" "		"	1,146		
50		P_2O_5	"		744	− 210
51	" "		"	762		

Root—mean—square—difference between neighbouring controls 289 lb. per acre.
Average yield of 32 unmanured plots 1,484 lb. per acre.

"	difference on	4	plots receiving	Nitrogen +	280±145	lb. per acre.
"	"	4	"	Phosphates +	134±145	" "
"	"	4	"	Potash +	68±145	" "
				Nitrogen +		
"	"	4	"	Phosphates +	267±145	" "
				Potash +		
				Phosphates −		
"	"	4	"	Nitrogen +	86±145	" "
				Potash +		
"	"	4	"	Nitrogen +	255±145	" "
				Phosphates +		
				Potash +	321±145	" "

VARIETY ... ... LAGOS WHITE.
Ridged ... .. July 17th.
Planted ... ... September 1st.
Supplied ... ... September 10th and 24th.
Weeded ... ... September 1st, 20th, October 11th and 25th.
Harvested ... ... January 5th.

Each plot $\frac{1}{72}$ acre ridges 6′ apart; plants 18″ apart on each side of the ridge, 1 plant per stand.

Rate of application.

Nitrogen as sulphate of ammonia ... 1 cwt. per acre.
Phosphate as Superphosphate ... 3 " " "
Potash as Muriate of Potash ... $\frac{1}{2}$ " " "

Method of application.

Phosphates and Potash sown broadcast prior to ridging.
Nitrogen scattered along both sides of ridges three weeks after planting.

Germination percentages:

Controls	94%	Nitrogen	+	Phosphate	94%
Plots receiving Nitrogen ...	94%	Phosphate	+	Potash	94%
" " Phosphate ...	91%	Nitrogen	+	Potash	94%
" " Potash ...	92%	Potash	+	Nitrogen	
			+	Phosphate	94%

TABLE No. 10.

Trial of Calcium Cyanamida on Late Maize, 1928.

Plot.	Treatment.	Crop.	Yield in lb. dry grain per acre.	Increase (+) or decrease (−) with mean of adjacent controls.
B6				
1	No Manure	Maize	2,756	
2	2 cwt. Calcium Cyanamide per acre	„	2,978	+267
3	No Manure	„	2,666	
4	2 cwt. Calcium Cyanamide per acre	„	2,344	+ 55
5	No Manure	„	1,911	
B7				
1	No Manure	„	1,656	
2	2 cwt. Calcium Cyanamide per acre	„	2,311	+ 88
3	No Manure	„	2,789	
4	2 cwt. Calcium Cyanamide per acre	„	2,800	+528
5	No Manure	„	1,756	

Root—mean—square—difference between neighbouring controls 856 lb. per acre.

Average yield of 6 plots, unmanured 2,254 lb. per acre.

„ difference of 4 plots manured with Calcium Cyanamide + 235 ± 428 lb. per acre.

Variety	Lagos White.
Ridged	July 16th.
Planted	September 3rd.
Supplied	September 10th and 24th.
Weeded	August 4th, September 3rd, 20th, October 9th, 24th, November 24th.
Harvested	January 2nd.

Each plot 0·09 acre. Ridges 6′ apart stands 18″ apart on each side of the ridge, 1 plant per stand.

Germination percentage 96%.

TABLE No. 11.

RIDGING *versus* MOULDING, 1928.

Plot.	Treatment.	Crop.	Yield of undecorticated nuts in lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
Z7N					
1	Ridged	Groundnuts.	1,784		
2	Moulded ...	,,		1,488	−246
3	Ridged	,,	1,684		
4	Moulded ...	,,		1,700	− 92
5	Ridged	,,	1,900		
6	Moulded ...	,,		1,800	+ 72
7	Ridged	,,	1,556		
8	Moulded ...	,,		1,728	− 22
9	Ridged	,,	1,944		
10	Moulded ..	,,		1,848	− 8
11	Ridged	,,	1,768		
12	Moulded ...	,,		1,744	+162
13	Ridged	,,	1,396		
14	Moulded ...	,,		1,476	− 8
15	Ridged	,,	1,572		
16	Moulded ...	,,		1,564	+ 36
17	Ridged	,,	1,484		
18	Moulded ...	,,		1,660	+176
19	Ridged	,,	1,484		
20	Moulded ...	,,		(1,424)	Not Experimental.
	Average.		1,657		+70

Average yield of 10 plots *Ridged* ... ... 1,657 lb. per acre.
„ difference of 9 plots *Moulded* ... ... + 70 ± 81 „ „

Root—mean—square—difference between neighbouring controls 243 lb. per acre.

Variety—Native Zaria.

Ridged, moulded, February 27th–March 6th. Planted, March 20th. Supplied, April 16th. Weeded, April 19th, May 4th, 26th, June 6th and 28th. Harvested, August 22nd–28th.

Germination prior to supplying ridged plots 90·7%
moulded „ 87·0%

¼ acre plots. Ridges 6′ apart. Stands 12″ apart on each side of ridge.

Cost of ridging per acre	=	27½ man days.
„ moulding per acre	=	5½ „
Saving in labour due to moulding	=	22 „
Increase in gross return per acre due to moulding (70 lb. undecorticated nuts at 1d. per lb.)	=	5½ „
Nett increase profit per acre due to moulding	=	27½ „

TABLE No. 12.

HAND-WEEDING *versus* REGULAR HOE-CULTIVATION, 1928.

Plot.	Treatment.	Crop.	Yield in lb. per acre, Undecorticated Nuts.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Z78				
21	Hoe cultivated	Ground-nuts	2,128	
22	Hand weeded.	„	1,848	−222
23	„	„	2,012	
24	„	„	1,932	− 60
25	„	„	1,972	
26	„	„	1,472	−364
27	„	„	1,700	
28	„	„	1,824	+ 24
29	„	„	1,900	
30	„	„	1,972	+ 50
31	„	„	1,944	
32	„	„	2,172	+222
33	„	„	1,956	
34	„	„	1,900	+ 2
35	„	„	1,840	
36	„	„	1,696	−268
37	„	„	2,088	
38	„	„	1,916	− 4
39	„	„	1,752	
40	„	„	(1,652)	(Not experimental.)
	Average		1,929	−620

Average yield of 10 plots hoe-cultivated weekly 1929 lb. per acre.

„ difference of 9 plots hand-weeded ... ... −620 ± 63 lb. per acre.

Root—mean—square—difference between neighbouring controls 188 lb. per acre.

Moulded, March 7th; Planted, March 21st; Supplied, April 16th;

Hoe-cultivated, weekly (Odd plots), April 20th, May 5th and 9th, June 2nd, 9th, 16th and 23rd and July 7th.

Hand-weeded when necessary (Even plots); April 21st, May 4th and 28th, June 6th, 7th and 22nd, July 2nd and August 2nd.

Harvested August 22nd–30th.

¼ acre plots Ridges 6′ apart stands 12″ apart on each side of ridge.

Cost per acre of hand-weeding	= 53 man days.
„ „ „ hoe-weeding	= 38 „ „
Saving in labour due to hoe-cultivation	= 15 „ „
Increase in gross return per acre due to hoe-cultivation (620 lb. undecorticated nuts at 1d. per lb.)	= 48 „ „
Nett increase profit due to hoe-cultivation	= 63 „ „

TABLE No. 13.

COTTON VARIETY TEST, 1928.

Plot.		Variety.	Yield in lb. seed cotton per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
D5N	1	Meko	424	
	2	Ishan A	624	+264
	3	Meko	295	
	4	Ishan B	407	+134
	5	Meko	250	
	6	Ishan H	292	+ 35
	7	Meko	263	
	8	Ishan A	624	+350
	9	Meko	284	
	10	Ishan B	354	+ 76
	11	Meko	271	
	12	Ishan H	264	+ 12
	13	Meko	233	
	14	Ishan A	611	+362
	15	Meko	264	
	16	Ishan B	330	+ 58
	17	Meko	279	
	18	Ishan H	219	− 83
	19	Meko	324	
	20	Meko	(338)	Non-experimental.
D6S	21	Meko	579	
	22	Ishan A	780	+311
	23	Meko	359	
	24	Ishan B	313	− 19
	25	Meko	305	
	26	Ishan H	168	−102
	27	Meko	235	
	28	Ishan A	598	+357
	29	Meko	246	
	30	Ishan B	286	+ 60
	31	Meko	206	
	32	Ishan H	170	− 47
	33	Meko	227	
	34	Ishan A	590	+367
	35	Meko	215	
	36	Ishan B	242	+ 6
	37	Meko	256	
	38	Ishan H	300	− 21
	39	Meko	385	
	40	Meko	(482)	Non-experimental.
		Average	295	...

TABLE No. 13—*continued.*

	lb. seed cotton per acre.
Average yield of 20 plots, Meko	295
,, difference of 6 plots, Ishan A ...	+336±31
,, ,, ,, 6 ,, Ishan B ...	+ 53±31
,, ,, ,, 6 ,, Ishon H ...	− 34±31

Ridged June 27th–30th; Planted July 6th; Supplied July 20th, August 29th; Weeded July 23rd, August 1st and 17th, September 3rd, October 25th, December 18th; Moulded August 16th, September 4th, 26th, 27th. Harvested December 21st and 24th, January 5th, 6th, 17th, 22nd, 26th and 29th, January 5th, 6th, 12th, 13th, 19th, 20th and 25th, March 1st and 4th.

¼ acre plots. 6′ ridges. Stands 4′ apart, staggered, on each side of the ridge, 1 plant per stand.

Germination percentages Meko	83 %
,, ,, Ishan A	93 ,,
,, ,, ,, B	86 ,,
,, ,, ,, H	94 ,,

TABLE No. 14.
Coconuts, 1928.
Planted 1912.

Plot.	Acreage.	Planting Distance.	No. of trees at end of year.			Vacancies.	No. of collections.	Total yield of nuts.
			Bearing.	Non-bearing.	Young Plants.			
B1	5	30′ × 30′	176	16	3	47	6	8,879
C1	5	25′ × 25′	209	72	12	45	6	4,850

No classification of nuts was done.

TABLE No. 15.
Cocoa Yields, 1928.

Plot.	Acreage.	Variety.	Planted.	Yield per acre lb.	
				Wet Beans.	Dry Beans.
A1 ...	2·5	Yellow pod	1912	1,182	
Y1 ...	4·75	Red pod	1912	518	303

Separate figures for dry beans in each plot are not given as the crop of wet beans from both plots was mixed for the purpose of another experiment.

TABLE No. 16.

Kola (Gbanja), 1928.

$2\frac{1}{2}$ acres. Planted 15′ × 15′ in 1913.

Plot.	No. of collections.	No. of pods.	Weights of pods lb.	No. of Nuts, good or bad.	Weights of good nuts lb.	Yield of nuts in lb. per acre.
Y5	23	1,407	790	7,769	219	88

TABLE No. 17.

Cost of Cultivation of main Crops—1928.

Figures in man-days per acre, obtained from plots of the Main Rotation.

Crop.	Preparation.	Establishing.	After cultivation.	Harvesting.	Store work.	Total.	
Yams	26	38	25	17	5	111	
Green Manure and	2·5	6	7	...	...	15·5	141·5
Cotton	36	6·5	34	38	11·5	126	
Groundnuts and ...	29	12	36	62	12	151	168
Cover Crop ...	3	6	8	...	..	17	
Maize and	26	9	17	11	5	68	81
Cover Crop ...	5	2	6	...	...	13	
Late Maize	16	7	9	11	9	52	

TABLE No. 18.

Comparison of Cost of Production and Revenue for Main Rotation Crops, 1928–29 Season. Moor Plantation.

Average Cost of labour for year 1s. 0½d. *per man-day.*

Crops.	Cost of crops in man-days per acre.	Average yield in lb. per acre.	Cost of production of crop in man-days per lb.	Market value per lb. at store.	Calculated return per acre.	Gross Monetary return per man-day.	Nett Monetary return per man-day.	Kind of crop.
Yams, Gross ...	111	5,156	·022	·435d.	2,243d.	20·2d.	+ 7·7d.	Tubers.
„ Nett ...	111	3,018	·037	·435d.	1,313d.	11·8d.	− 0·7d.	„
Cotton Meko ...	126	295	·427	1·53d.	451d.	3·6d.	− 8·9d.	Seed cotton.
„ Ishan ...	126	631	·200	2·18d.	1,376d.	10·9d.	− 1·6d.	„ „
Groundnuts ...	151	1,793	·084	·984d.	1,764d.	11·7d.	− 0·8d.	Undecorticated.
Early Maize ...	68	1,980	·034	·375d.	743d.	10·9d.	− 1·6d.	Husked cobs.
Late Maize ...	52	1,139	·046	·562d.	640d.	12·3d.	− 0·2d.	„ „

ANNUAL REPORT, UMUAHIA PLANTATION, 1928.

The following officers were in charge :—

Mr. S. M. Gilbert, B.Sc., N.D.A., from 1st January to 11th March.

Mr. J. L. B. Kincaid, B.Sc., from 12th March to 8th April.

Mr. D. H. Urquhart, B.Sc., „ 9th April to 31st December.

Experiment I.

Cover Crop Test. D1—41.

In this experiment three cover crops were tested against Mucuna.

The crops were sown down in early May.

Mucuna germinated well and gave the best cover in the early stages. It reached its maximum growth about July. By October it began to die back, and by the end of December it had almost completely died. There appears to be a good bulk of dead material left on the ground.

Centrosema, although slower growing than mucuna, developed well. It formed less bulk of leaf and stem than mucuna but lasted much better than any of the other cover crops through the dry season.

Crotolaria was slow in germinating and the germination was very irregular. It was very slow to "come away" after germinating. It did not form a close cover. Some of the plots developed well, but the cover on the plots was irregular.

Calapogonium was slow to develop. It took fully eight weeks to cover. When the crop developed properly it made a very close cover. It seems to form a large bulk of material.

The conclusions that might be drawn from this test, at the present stage, are that Mucuna is the quickest grower, and forms the greatest cover in the shortest time. Centrosema and Calapogonium are both slower growers, but last better than mucuna into the dry season. Calapogonium possibly forms more bulk of dead material than even mucuna. Crotolaria is not suited for use as manure for annual crops on this farm, owing to its irregular germination and the uneven cover formed. It is of little use for suppressing weeds. The amount of dead material left on the ground for the following year's crop is much less than with the other cover crops. It is probably best suited for use as a shade for young seedlings such as cocoa.

Experiment II.

To grow Mucuna to supply seed for sowing down at latter end of Rainy Season. D42—61.

This block was sown in mucuna in May, and staked with the idea of getting seed for sowing down in other plots in time to get a cover of mucuna before the dry season was too far advanced. The first seed was harvested in October, but only a small quantity was available before the beginning of November. It would appear that it would be better to sow mucuna, say about July and harvest the following January for seed purposes.

Experiment III.

Maize Spacing Experiment. F42—61.

There was a slight difference in favour of the two feet spacing as against the one foot spacing. The percentage of bearing stands was higher in the plots with two feet spacing. It is considered that the closeness of sowing could entirely account for the lower counts in the one foot spaced plots. This experiment is being repeated in 1929.

Table No. 1.

Experiment IV.

Once farmed land left to bush versus *continuously farmed land. M1—25.*

The continuously farmed plots have now been cropped for six years in succession. The yield of yams this year is satisfactory and the yield of maize is quite fair, considering previous average yields on this farm. Groundnuts were a failure. As groundnuts have never been successful on the farm this result was rather expected.

The results from this experiment at present would seem to indicate that a rotation such as is followed on the continuously farmed plots, *viz* :—yams, maize, groundnuts, is worthy of further investigation. If an edible bean be substituted for groundnuts, this should prove a useful short rotation where each food crop has a cover interplanted about the middle of the rains, as is done in the above rotation, to provide manure for the following year's food crop.

An average gross yield of 5,044 lb. of yams in 1927 was good, and an average gross yield of 5,260 lb. this year is considered very good, considering the two types of yams planted this year are comparatively light yielders. The average nett yield was 3,384 lb.

It is proposed to put this block under a test crop in 1930.

Experiment V.

Late Mucuna versus *Late Dolichos as a preparation for early Maize. M26—32.*

Although the yields on these plots have rapidly decreased since 1926, the yield this year is in favour of Dolichos. Mucuna has always been the much bulkier crop. We have not yet succeeded in getting a heavy crop of Dolichos on the farm. This experiment is being continued.

Table No. 2.

Experiment VI.

Early Mucuna versus *Early Dolichos as a preparation for late Maize. M33—41.*

The yield of maize over the block was low. The slight difference in yield was in favour of the Dolichos plots.

Table No. 3.

Experiment VII.

Comparison of five different Rotations with a standard Rotation. P3—41.

The maize crop was poor.

The cover crop in 1927 was poor and there was only a very small bulk of material to dig into the soil. A thick seeding of mucuna will be made early in 1929 to endeavour to get this land into cropping condition.

Experiment VIII.

Native farming versus *Continuous cropping. Q1—17.*

This bock is now under what is considered, possibly, the most interesting of the annual crop experiments. The rotation, which was commenced in 1925, is a trial of what is a fairly intensive rotation against what is usual native farming in this District. The native farms are under a rotation of yams and maize in the first year, with cassava planted about June. The cassava is harvested in the following June or July and then the land goes to bush for four years.

In the intensive rotation, yams and maize in the first year are followed by a green manure in the second year. In the third year, a maize crop is sown and interplanted with mucuna to provide manure for yams in the fourth year. For the fifth year the land is left for a whole season under green manure, followed by groundnuts, or, if possible, an edible bean, in the sixth. With this distribution of cover crops between food crops, it is hoped to keep up the fertility of the soil.

The continuously farmed plots in Q1—17 have given an average gross yield of 3,971 lb. and an average nett yield of 2,413 lb. of yams in the fourth year of the rotation. As the yams planted were of a light yielding type, the result is considered good.

The gross yield on these same plots when they were planted down in 1925 from high bush was 4,094 lb. of yams.

Plots in Q18—34, which are in the third year of the rotation, gave an average yield of maize of 718 lb. per acre. This yield, considering the yields got on the farm previously, is satisfactory.

The cultivated plots in Q35—51, which are in the second year of the rotation, grew a heavy crop of mucuna. By carefully cutting back this crop about three times during the season when it showed signs of coming into flower, the cover was prolonged well into November. Cassava was harvested from the native farmed plots, giving 1,720 lb. to the acre.

R1—17, which is under the first year of the rotation, gave a most satisfactory yield as regards yams. There is the significant difference of 43 : 1 in favour of the yield on the stumped and ridged plots compared with native practice plots.

This is the first occasion on which a significant difference has been noted.

Average yields, in the first year, of yams—in land planted down from high bush—has been about two tons to the acre. The gross yield of over four tons, with a nett yield of 7,133 lb. to the acre in this block, is looked on as rather a triumph considering the poorness of the soil.

The evenness of germination and yield on all plots is particularly satisfactory. The lower yield in R1 is accounted for by the fact that it was next to the high bush and suffered from the depredations of buck and rodents.

Table No. 4.

With regard to the maize yield on this block, the results are overwhelmingly in favour of the stumped and ridged plots as compared with the native practice plots. Throughout all blocks under the experiment, the plots in the native practice plots are handed over to local farmers after they have been cutlassed and cultivated.

The table of man-days for different operations on R1—17 (Table 5) is instructive. Preparation of the unstumped and ridged plots was more expensive to the extent of twenty days as compared with the native practice plots. Preparation of the stumped and ridged plots cost 171 more man-days than the native practice plots and 141 more man-days than the unstumped and ridged plots. It would appear that, for growing of annual crops, complete stumping of the land in the first year will prove uneconomical. This idea is confirmed by the yields of maize on H31—39 in 1928 which are discussed later.

Experiment IX.

Coffee. G11—20.

Five acres of Liberian coffee were planted from seedlings germinated in the nursery, and were planted out—on ridged, unstumped land at 8′ × 8′ spacing, with a wind-break of rows of alternately planted Mangoes and Kola trees, dividing the half acre plots in the east and west direction.

The coffee made very good progress throughout the year. A cover crop of Centrosema was sown down in June. This cover is well suited for use among young coffee.

Experiment X.

Oil Palm Variety Experiment. H21–49.

Good progress has been made with establishing progeny of high yielding palms of different varieties from Calabar. A set-back was suffered through the destruction of many young seedlings by wild rodents. Thirty-six seedlings were destroyed in this way in the month of September. Spring traps were set without any success. Eventually, we surrounded the younger seedlings with wire netting. It is difficult to account for such a vigorous attack by these animals on the young palms as the plots are not surrounded by high bush. It is possible that the close cover afforded by Calapogonium attracted them in the first instance.

The Calapogonium was sown broad-cast about 20th March. The seeding was light, only about three lb. per acre. The seed was very slow to germinate. It was not until June that a cover was

formed. After this date it developed well, until the beginning of December when it began to die off. Probably, had a firmer seedbed been provided, it would have germinated earlier and come away more quickly.

The cover crop was cut back three times, *viz.* :—once in July, and again in August and September, when it showed signs of flowering. This of course greatly prolonged its life.

Experiment XI.

Oil Palms in coppiced and cropped land versus *Oil Palms in land coppiced only. H21–29.*

From this experiment, commenced about June, 1925, it would now appear that the palms in the cropped land are developing distinctly better than the palms in the adjacent plots which are coppiced only. In view of the extension work in improving "Palm Bush" and establishing oil palm plantations, this experiment promises to give interesting results. If we show the farmer that he can crop between the young palms for the first five or six years, not only without harming them but with benefit to the young plants, we shall remove one of the greatest difficulties of the small planter, *viz.* :—the cost of establishing a palm plantation. Where annual cropping is practised between palms, the cost of establishing a palm plantation in the first few years is reduced to a minimum.

Coco yams were planted with maize intersown on the farmed plots. An average of 3,289 lb. of coco yams were harvested per acre, and 465 lb. per acre dry grain of maize. The yield of coco yams is good, considering the area occupied by the palms. The maize yield, considering it was interplanted among coco yams, was quite satisfactory.

Experiment XII.

Oil Palm in Coppiced and Cropped Land versus *Oil Palms in stumped and cropped land. H31–39.*

The palms were planted down as seedlings in 1923. Two plots were stumped and cleared, and cropped between palms, three plots had the palm seedlings planted in six feet rides. This was meant to be a comparison between establishing palms cheaply without removing the bush and the more costly method of stumping. It soon became evident that the seedlings in the high bush made very slow progress compared with the seedlings in the cleared land. So in 1925 the bush was cut back and the seedlings

protected and the bush burnt. The whole of the land was then cropped and the experiment became a comparison between palms growing in the cleared and stumped land and palms in coppiced, unstumped land, the land being similarly cropped in both cases. The trees in the cleared land look better developed. Of course, when the bush plots were cut back in 1925, the plots which had been cleared in 1923 looked very much superior. This superiority is becoming much less marked each year. From superficial observation the advantage of stumping would appear to be small. From Table 6, it will be seen that an average of forty-eight *per cent.* of the trees are now in bearing in the cleared plots as against an average of twenty-two *per cent.* in the plots which started life in high bush.

Experiment XIII.

Oil Palms in continuously cropped land versus *Oil Palms in land once farmed and allowed to go to bush.*

The oil palms in the cleared land are very definitely superior to the palms in the bush plots.

In 1930 it is proposed to cut, burn and farm one of the bush plots. It should be an interesting comparison between the palms which are being grown in the open with the intermediate land cropped with food crops as against the conditions which will obtain in the bush plots. The bush plots will correspond to local native treatment of palms. A considerable amount of labour is being expended on mulching round the plants in the bush plots, and slashing back the bush in the immediate vicinity of the plants.

The cleared plots were cropped with maize this year, with mucuna intersown.

Experiment XIV.

Comparison of farm land without Oil Palms and land with Oil Palms in varying numbers. H51–67.

This block was cropped with yams this year and gave a satisfactory average gross yield of over 5,800 lb. per acre and a nett yield of 4,827 lb. Over this whole block, different varieties of yams were used, with, of course, equal numbers of each variety in each plot. This is a high nett yield of yams although the rate of seeding is low (due to the fact that small seed yams were used to a great extent, instead of larger yam sets as was done elsewhere).

The yield from plots with twenty-one palms and, again, from plots with thirty-three palms is slightly less than that from the standards where no palms are planted. In the latter case the difference is more marked. As would be expected, taking into account that the trees are only about two and a half years old, the difference in either case is not significant.

Table No. 7.

Experiment XV.

Mulching Experiment on Cocoa J26–40.

Earth mulching and vegetable mulching, in the dry season, were tried against unmulched plots. Although the cocoa is too poor to respond to any treatment, the plantains, which were planted as shade plants for the young cocoa, responded to the treatments in a very remarkable manner.

At the end of the 1927–28 dry season, the plantains which were mulched during the dry season were between seven and ten feet high. The plantains which were not mulched were between three and five feet high. During the wet season all plots were cultivated and planted down to cover crops, but the plants which had not been mulched remained stunted throughout the year.

The same experiment was carried on through the 1928–29 dry season with equally striking results.

Experiment XVI.

Treatment of young Cocoa. J41–50.

The land between cocoa in the control plots was sown with cover crops, and then earth-mulched in the dry weather. The experimental plots were sown to maize with mucuna intersown later. These plots are to be mulched in the dry season. As the experiment was only commenced in 1928, no difference is yet noticeable.

Rice.

A small area of swamp rice was grown. The area of swamp available is not sufficient for carrying out an experiment with this crop on a large scale.

TABLE No. 1.

MAIZE SPACING EXPERIMENT.

Plot No.	Treatment.	Percentage bearing plants.	Yield Dry Grain per acre. lb.		Increase (+) or decrease (−) compared with mean of neighbouring controls.
F 42	2 feet apart ...	31	160		
43	1 foot „ ...	17		120	− 24
44	2 feet „ ...	27	128		
45	1 foot „ ...	23		172	+ 26
46	2 feet „ ...	36	164		
47	1 foot „ ...	27		236	− 60
48	2 feet „ ...	57	488		
49	1 foot „ ...	39		400	− 142
50	2 feet „ ...	63	596		
51	1 foot „ ...	44		648	+ 90
52	2 feet „ ...	62	520		
53	1 foot „ ...	35		488	− 112
54	2 feet „ ...	69	680		
55	1 foot „ ...	40		536	− 108
56	2 feet „ ...	66	608		
57	1 foot „ ...	41		616	+ 46
58	2 feet „ ...	55	532		
59	1 foot „ ...	35		364	− 108
60	2 feet „ ...	47	412		
Average	...	43	402		46·88

Date of planting, 11th April, 1928.

Date of harvesting, 2nd August, 1928.

One plant at a stand.

Six feet ridges.

Stands in two rows per ridge staggered, *i.e.*, theoretical space per stand is six square feet in the case of two feet spacing.

Root—mean—square difference between neighbouring control plots = 139·72 lb. per acre.

Average yield of 10 control plots = 402 lb. per acre.

Average difference of 9 plots sown at 1′ apart = 46·88 ± 46·573.

Odds that difference is significant = 2 : 1.

TABLE No. 2.

YIELD OF EARLY MAIZE IN LB. DRY GRAIN.

Plot No.	Treatment.	1925.	1926.	1927.	1928.	Remarks.
M 26	Maize following Mucuna	1,263	1,196	500	392	
27	„ „ Dolichos	1,167	1,516	416	456	
28	„ „ Mucuna	998	1,632	652	396	
29	„ „ Dolichos	1,141	1,352	656	540	
30	„ „ Mucuna	1,056	1,184	732	548	
31	„ „ Dolichos	1,096	1,324	724	580	
32	„ „ Mucuna	1,093	1,204	724	500	

DETAILS FOR 1928 ONLY.

Date of sowing, 6th April, 1928.

Date of harvesting, 1st August, 1928.

Each plot = $\frac{1}{4}$ acre.

Six feet ridges.

Maize planted $1\frac{1}{2}$ feet apart, staggered, thinned to one plant at a stand, *i.e.*, approximate space per plant = 4 sq. ft.

Labour cost per acre = 65 man-days.

Root—mean—square—difference between neighbouring control plots = 92·054 lb. per acre.

Average of four control plots following Mucuna = 434 lb. per acre.

Average difference of three plots following Dolichos = + 62 ± 53·149.

Odds that difference is significant = 7 : 1.

TABLE No. 3.

YIELDS OF LATE MAIZE IN LB. DRY GRAIN.

Plot No.	Treatment.	1925.	1926.	1927.	1928.	Remarks.
M 33	Mucuna and late Maize ...	60	212	228	164	
34	Dolichos „ „ „ ...	36	122	280	160	
35	Mucuna „ „ „ ...	76	134	276	184	
36	Dolichos „ „ „ ...	116	100	224	148	
37	Mucuna „ „ „ ...	100	106	296	108	
38	Dolichos „ „ „ ...	116	154	284	136	
39	Mucuna „ „ „ ...	96	168	356	80	
40	Dolichos „ „ „ ...	60	90	232	80	
41	Mucuna „ „ „ ...	32	102	132	32	
	Yields in favour of ...	Mucuna	Mucuna	Mucuna	Dolichos	

DETAILS FOR 1928 ONLY.

Date of sowing, 10th August, 1928.

Date of harvesting, 10th December, 1928.

Each plot = ¼ acre.

Six feet ridges.

Maize planted, 1½ feet apart, staggered, thinned to one plant at a stand, *i.e.*, approximate space per plant = 4 sq. ft.

Labour cost per acre = 39 man-days.

$$R = 48{\cdot}215 \text{ lb. per acre.}$$

Average yield of five control plots following Mucuna = 110 lb.

Average difference of four plots following Dolichos = 13·5 $\pm$24·108.

Odds that difference is significant = 2 : 1.

TABLE No. 4.

YAMS — NATIVE PRACTICE *versus* (*a*) STUMPED AND RIDGED. (*b*) UNSTUMPED AND RIDGED.

Plot No.	Treatment.	Percentage Germination.	Yield of Tubers lb. per acre.		Weight of sets planted lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.	Nett Yield of Yams lb. per acre.
R 1	Native Practice	94	7,152		1,932		5,220
„ 2	Stumped and Ridged	94		9,768	2,060	+ 1,488	7,708
„ 3	Native Practice	88	9,048		2,332		6,716
„ 4	Unstumped and Ridged	96		10,188	2,256	+ 766	7,932
„ 5	Native Practice	94	9,796		2,180		7,616
„ 6	Stumped and Ridged	93		9,904	1,812	− 508	8,092
„ 7	Native Practice	94	8,996		1,776		7,220
„ 8	Unstumped and Ridged	96		9,260	2,204	− 16	7,056
„ 9	Native Practice	94	9,556		2,048		7,508
„ 10	Stumped and Ridged	92		10,088	2,192	+ 1,292	7,896
„ 11	Native Practice	96	8,216		2,216		6,000
„ 12	Unstumped and Ridged	96		8,464	2,356	− 156	6,108
„ 13	Native Practice	85	8,400		2,260		6,140
„ 14	Stumped and Ridged	98		9,036	2,084	+ 364	6,952
„ 15	Native Practice	98	8,944		2,160		6,784
„ 16	Unstumped and Ridged	96		8,776	2,112	− 170	6,664
„ 17	Native Practice	96	8,948		2,300		6,648

Date of planting, 9th March, 1928.

Date of harvesting, 2nd November, 1928.

Six feet ridges.

Yams planted 4 feet staggered = 1,700 stands per acre, *i.e.*, approximate space per plant = 25 square feet.

Root—mean—square—difference between neighbouring control plots = 865·35 lb. per acre.

Average yield of 9 control plots Native Practice 8,785 lb. per acre.

(1) „ difference of 4 plots stumped and ridged + 890·5 ± 432·675.

(2) „ „ of 4 plots unstumped and ridged + 184 ± 432·675.

(1) Odds that the difference is significant ... = 43 : 1.

(2) „ „ „ „ „ „ less than ... 2 : 1.

TABLE No. 5.

R1-17 Rate of Payment 9d. per day.

LABOUR COSTS IN MAN-DAYS.

Yams intersown with Maize. Working day is 8½ hours.

Treatment.	Preparation.	Establishing.	After Cultivation.	Harvesting.	Totals.
9 Native Practice Plots.	31	19	41	13	104
4 Unstumped Ridged Plots.	51	19	41	13	124
4 Stumped Ridged Plots	202	19	41	13	275

TABLE No. 6.

OIL PALM YIELDS 1928.

Plot No.	Treatment.	No. of Trees harvested.	Percentage of total trees in plot harvested.	Average No. bunches per yielding tree.	Average weight of fruits per bunch in lb.	Total weight of fruits as percentage of total weight of bunches in lb.	Average weight of fruit per yielding tree in lb.
H 31	Unstumped and Cropped	17	26%	5	1	55%	8
.. 33	Stumped and Cropped ...	39	60%	8	2	60%	12
.. 35	Unstumped	15	23%	4	2	68%	9
.. 37	Stumped and Cropped ...	24	37%	9	2	64%	19
.. 39	Unstumped	11	17%	2	2	9%	2

Each plot = 1 acre.

Trees planted = 65 per acre.

TABLE No. 7.

Yams.

Cropping through Palms at varying Densities per Acre.

Plot No.	Treatment.	Yields lb. Tubers per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.		Weight of sets sown in lb. per acre.	Nett yield in lb. per acre.
H 51	Nil Palms	5,289				1,347	3,942
„ 53	21 „		5,065	− 560		1,240	3,825
„ 55	Nil „	5,962				1,212	4,750
„ 57	33 „		4,844		− 1,588	1,207	3,637
„ 59	Nil „	6,903				1,180	5,723
„ 61	21 „		6,871	+ 108		1,188	5,688
„ 63	Nil „	6,634				1,129	5,505
„ 65	33 „		6,553		+ 599	1,048	5,505
„ 67	Nil „	5,274				1,127	4,147
	Average	6,013		− 226	− 494·5	1,186	4,827

Date of planting, 14th March, 1928.

Date of harvesting, 18th October, 1928.

1 acre plots.

6 feet ridges.

Yams planted $4\frac{1}{2}$ feet apart, staggered, *i.e.*, approximate area per plant = 28 square feet.

R = 902·83 lb. per acre.

Average yield of five control plots without palms 6,013 lb. per acre.

(*a*) „ difference of two plots with 21 palms − 226 ± 638·49

(*b*) „ „ „ „ „ „ 33 „ − 494·5 ± 638·49.

(*a*) Odds that the difference is significant is less than 2 : 1

(*b*) Labour cost per acre of Yams = 165 man-days.

TABLE No. 8.

RAINFALL UMUAHIA.

Month.	Average Rainfall in inches taken over five years 1923 to 1927 inclusive.	Rainfall in inches, 1928.
January	1·38	3·12
February	·98	Nil
March	3·17	8·90
April	10·88	9·33
May	12·25	10·09
June	16·55	9·75
July	9·79	7·69
August	14·22	11·85
September	14·46	16·49
October	11·55	6·24
November	2·64	2·05
December	·9	2·45
Total	97·96	87·96

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The following officers were in charge :—

Mr. G. W. Lines, B.A., from 1st January to 23rd September.

,, J. W. Wallace, B.Sc., from 24th September to 7th October.

,, J. L. B. Kincaid, B.Sc., from 8th October to 31st December.

Experiments have been carried on during the year 1928 on similar lines to former years. Most of the experiments have been designed for the purpose of studying green manuring practice for annual crops, and with a view to finding a rotation of crops suitable for the area.

The season was definitely abnormal in that the months of January and the previous December were very wet, and the farm thus did not experience the definite dry season which is usual at Benin. The rainfall otherwise was well distributed during the growing season and was favourable to the early maize crop, which was generally good.

Cover Crop Experiments.

a) Time of cutting cover crop experiment 1928. Table No. 1.

This experiment was commenced in 1927 with the object of comparing plots in which Mucuna is cut and dug in at the end of the wet season with plots in which the cover crop is cut and dug in at the beginning of the following year's rains. The bulk of Mucuna buried in November was considerably greater than of that buried in February. The yields were as follows :—

	Yield of maize in lb. dry grain per acre.	Odds that difference is significant.
Average yield of 5 plots with Mucuna dug in November	1,006	—
Average difference of 4 plots with Mucuna dug in February	+393±133	740 : 1

These results may probably be accounted for by the fact that nine inches of rain fell during December and January at Benin.

This heavy rainfall, during months which are generally dry, must have caused rapid notification and loss of nitrates.

(*b*) Treatment of cover crop experiment 1928. Table No. 2.

The yields obtained from the early maize test crop showed similar results to those obtained in 1927. The plots in which Mucuna was cut and dug in were slightly better than those in which the Mucuna was burned and dug in, but as in 1927 the difference was insignificant.

	Yield of maize in lb. dry grain per acre.	Odds that difference is significant.
Average yield of 5 plots with Mucuna burnt and dug in	805	—
Average difference of 4 plots with Mucuna cut and dug in	+ 51±47	6 : 1

Native Farming *versus* Continuous Farming.

The plots being farmed under native methods have all reverted to bush in each of the three sets of similar experiments commenced in 1925, 1926 and 1927 respectively. No results are thus yet available from this experiment.

Three Year Rotation Experiment.

An experiment has been started to test a three year rotation which it is hoped will prove suitable to the area.

Permanent Crops.

Several new experiments with oil palms, kola and coffee were commenced during 1928 on land which had proved too poor to permit of establishing cocoa. It was decided to discontinue several of the cocoa experiments as the cocoa was making unsatisfactory growth owing to poverty of soil. In one area oil palms have been planted at different spacings with a view to studying the effect of different planting distances on the oil palm. An experiment on interplanting kola and coffee has been commenced, the kola being planted at various densities per acre An experiment on interplanting of oil palms and coffee has been started, the oil palms being planted at various distances. In another area an experiment has been commenced on the effect of various manures in establishing cocoa on very poor soil.

TABLE No. 1.

Time of Cutting Cover Crop Experiment, 1928.

Plot.	Treatment.	Crop.	Yield of dry grain in lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
Block Z71–79					
71	Cover crop cut and dug in—November	Early Maize	1,059		
72	Cover crop cut and dug in—February	,,		1,513	+ 387
73	Cover crop cut and dug in—November	,,	1,193		
74	Cover crop cut and dug in—February	,,		1,477	+ 362
75	Cover crop cut and dug in—November	,,	1,037		
76	Cover crop cut and dug in—February	,,		1,453	+ 378
77	Cover crop cut and dug in—November	,,	1,113		
78	Cover crop cut and dug in—February	,,		1,316	+ 445
79	Cover crop cut and dug in—November	,,	629		
	Average		1,006		

Cover crop Mucuna. Early Maize planted 23rd March, 1928, supplied 1st and 28th April, thinned 10th April and 1st May, harvested 25th July, 1928.

Each plot $\frac{1}{4}$ acre. Ridges 6 feet, 2 rows per ridge, stands 3 feet apart staggered, 2 plants per stand.

Root—mean—square—difference between neighbouring control plots 266 lb. per acre.

Average of 5 plots with cover crop dug in—November 1,006

Average difference of 4 plots with cover crop dug in—February + 393 ± 133

Control plots ridged 3rd December, 1927, experimental plots 28th February, 1928. Weeded 28th April, 18th July.

TABLE No. 2.

Treatment of Cover Crop Experiment, 1928.

Plot.	Treatment	Crop.	Yield of dry grain in lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
Block Y40–48					
40	Mucuna burnt ...	Early Maize	896		
41	Mucuna cut ...	,,		876	+ 23
42	Mucuna burnt ...	,,	811		
43	Mucuna cut ...	,,		850	+ 89
44	Mucuna burnt ...	,,	711		
45	Mucuna cut ...	,,		744	+ 22
46	Mucuna burnt ...	,,	733		
47	Mucuna cut ...	,,		872	+ 69
48	Mucuna burnt ...	,,	874		
	Average		805		

Maize planted 21st March, 1928, supplied 2nd April and 1st May, thinned 9th April and 1st May, harvested 31st July, 1928.

Each plot ¼ acre. Ridges 6 feet, 2 rows per ridge, stands 3 feet apart staggered, 2 plants per stand.

Root—mean—square—difference between neighbouring control plots 97 lb. per acre.

Average of 5 plots burnt and dug in 805

Average difference of 4 plots cut and dug in ... ... + 51 ± 47.

Ridged 8th March.

Weeded 27th April, 21st July.

TABLE No. 3.

Cost of Cultivation of Main Annual Crops, 1928.

Figures in man-days per acre obtained from Main rotation blocks.

Crop.	Preparation.	Establishing.	After cultivation.	Harvesting.	Store.	Total.
Yams	16	15	74	17	8	130
Early Maize ...	16	8	2	5	1	32
Cover Crops ...	17*	10	13	—	—	40
Cover Crops ...	10	4	25	4	—	43

* High cost due to re-ridging; early Maize followed by two Cover Crops.

TABLE No. 4.

Comparison of Costs of Production and Revenue for Main Rotation Crops.

1928–29 Season, Ogba Farm.

Cost of labour 11d. per man-day.

Crops.	Cost of crops in man-days per acre.	Average yield in lb. per acre.	Cost of production of crop in man-days per acre.	Market value per lb. at store.	Calculated return per acre.	Monetary return per man-day.	Kind of crop.
Yams Gross*	**130**	**8,656**	**·0150**	**·125d.**	**1,082d.**	**8·33d.**	**Tubers.**
Nett yield of Edible Yams	**130**	**6,423**	**·0202**	**·125d.**	**686d.**	**5·28d.**	**„**
Early Maize	**32**	**1,392**	**·023**	**·571d.**	**795d.**	**24·85d.**	**Dry grain.**

* The difference between gross and nett yield represents yams fit for seed only. The amount is roughly sufficient to plant one acre.

Rainfall 1928.

Ogba Plantation, Benin.

Month.	Rainfall in inches.	Average rainfall for previous five years, 1923–27.
January	4·95	·51
February...	·08	1·40
March	3·64	3·86
April	8·07	5·83
May	9·32	6·88
June	9·63	12·55
July	8·54	11·27
August	10·00	6·12
September	12·24	10·85
October	10·47	10·32
November	1·33	2·67
December	1·40	1·20
Total	79·67	73·46

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Total area of Experimental station 297 acres.

Area under cultivation 110 acres.

Latitude 8° 30′ North, Longitude 4° 34′ East.

Altitude 920 feet (approx.).

Mean Annual rainfall, 1905-28, 50·80 inches.

Distance from nearest point on coast 146 miles.

The following officers were in charge for the period shown:—

W. B. Dowson, April 1st, 1928—November 1st, 1928.

H. G. Poynter, November 2nd, 1928—March 31st, 1929.

Investigations were continued on the maintenance of fertility under the three year rotational scheme commenced in 1924, and a new three year rotation including groundnuts was started this season. Tests were again carried out with strains A. and B. of Ishan cotton *versus* Ilorin native; and between Chinese and Ilorin varieties of groundnuts; and also of planting this crop on new *versus* old ridges. A test was made of one row per ridge (native practice) *versus* two rows per ridge (our farm practice) of groundnuts.

Total rainfall was above normal, being 58·97 inches compared with the mean of twenty-four years, 50·80 inches. Although from these figures it appears to have been a satisfactory year from the point of view of the rainfall, the distribution of the rain (*see* Table I.) was rather abnormal; a drought of thirty-four days during a critical period for the early crops, July and August, resulted in the grain not maturing well, with a resultant low yield in early maize and groundnuts.

Groundnuts on the Experimental Farm were planted late. This was due to the preceding crops of Ishan cotton being left until late March to ensure maximum of information on the yield of this cotton. Such late planting adversely affected the yield of groundnuts. Local farmers allowed their groundnuts to remain in the ground until late February, the months of November and December being devoted to other food crops, so that the total tonnage of groundnuts for the province has been disappointing.

Groundnut Variety Test, Tables 2 and 3.

Two tests were carried out with Chinese var. compared with Ilorin var., in both cases the groundnuts were interplanted with guinea-corn and the trials were made on good soil (F 26–39) and poor soil (H 1–23) respectively. The Chinese nuts are approximately two weeks earlier in maturing than the local variety. They also possess a higher percentage of kernels, which are of superior quality. These various factors probably more than offset the slightly lower gross yield per acre. At Ibadan early maturity is a most important point.

The results were as follows :—

F 26–39.

Average of seven plots of Ilorin var. 1,206 lb per acre of dry unshelled nuts.

Average difference of six plots of Chinese var. — 161 ± 68 lb per acre.

Odds that the difference is significant. 121 : 1.

H 1–23.

Average of twelve plots of Ilorin var. 797 lb per acre of dry unshelled nuts.

Average difference of eleven plots Chinese — 106 ± 19 lb per acre.

Odds that the difference is significant over 1,000 : 1.

Groundnuts. Stale *versus* New Ridges. (Table 4.)

In this experiment the control plots were moulded up preparatory to sowing the groundnuts and the treatment plots had the ridges split and new ones made. The result of the test was as follows :—

Average of eleven plots on stale ridges 1,077 lb dry unshelled nuts per acre.

Average difference of ten plots on new ridges = + 67 ± 27 lb per acre unshelled nuts.

Odds that the difference is significant 160 : 1.

Although a definite increase in yield was found for the new ridges, the value of this increased yield did not pay for the extra labour involved.

Groundnuts—Var. Chinese (Table 5).

Two rows per ridge versus one row per ridge.

The result of this test showed that two rows to a ridge gave a definitely greater yield than one row. The result was as follows :—

Average yield of eleven plots two rows per ridge = 657 lb dry unshelled nuts per acre.

Average difference ten plots one row per ridge = − 169 ± 14·5 lb per acre.

Odds that difference is significant over 10,000 : 1.

Maize and Guinea-corn.

Demonstration Block for visiting farmers (Table 6).

This area was reserved for demonstrating to farmers the beneficial effect of mucuna as a preparation for maize with interplanted guinea-corn. The mucuna was sown in alternate plots through a block of guinea-corn in September, 1926. The beans were allowed to remain till October, 1927, when the ridges were split and the mucuna turned in. The other plots remained in weeds throughout 1927 but the ridges were split at the same time as the ridges on the mucuna plots. All plots were weeded over in May, 1928 prior to sowing maize.

	Lb. per acre dry grain.	Odds that difference is significant.
Average combined yield of maize and guinea-corn on 5 plots following mucuna	1,310	—
Average difference of 4 plots following no mucuna	− 412 ± 56 lb. per acre	—

The taller and healthier growth of maize following mucuna was very marked and much impressed farmers who saw it. The difference in height and particularly colour of the maize in July on alternate plots was noticeable half a mile away.

Maize.

As test Crop in Residual Value of Mucuna (Table 7).

The object here was to test the unexhausted value of mucuna sown one row on each flank of the ridge in alternate plots on September 7th, 1926. The mucuna was pulled and laid in the furrows in May, 1927. The control plots received no green manure. Yams were planted on the crests of the ridges in all the plots in

November, 1926. Yams in the mucuna plots therefore grew concurrently with the mucuna until the latter was pulled as described above. Yam yields in 1927 were as follows :—

	Lb. per acre.	Odds that difference is significant.
Average yield of 5 plots with mucuna ...	6,742	—
,, difference of 4 plots no mucuna	— 1,792 ± 432 lb. per acre	50,000 : 1

The early maize test crop this year gave definitely superior yields on the plots previously in mucuna.

	Lb. per acre. dry grain,	Odds that difference is significant.
Average yield of 5 plots previously in mucuna	792	—
Average difference of 4 plots no mucuna	— 197 ± 55 lb. per acre	10,000 : 1

It will be noted that the mucuna cover crop in this experiment was not immediately dug in, but gradually became incorporated with the soil. In period September, 1926—May, 1927, much more weeding was required on the plots not carrying mucuna. After the yams and before the maize the ridges were split. In the earlier stages of the maize this year, superiority of growth on the mucuna plots was very marked, so much so that the block was used for demonstration purposes to local farmers.

Cotton.

The work this season at Ilorin, as in previous years, has included yield tests on cotton, as a sole crop, and when grown through yams or groundnuts. A spacing test was also carried out with plants at one and half feet, two feet, two and half feet intervals.

Cotton Spacing Test. Table 8.

This test was carried out on C 41–60 on which the cotton, var: Ishan A, was grown through yams, var: Boki. The standard plots of cotton were planted at two feet and these were compared with others planted at one and half feet and two and half feet. The results of this test show that cotton planted at one and half feet and two and half feet gave a slightly lower yield than two feet, but the result is not significant.

Average of nine control plots at 2 ft. intervals 191 lb seed-cotton per acre.
Average difference of five plots at $1\frac{1}{2}'$ intervals — 17 ± 22
Average difference of four plots at $2\frac{1}{2}'$ intervals — 23 ± 25
Odds that the difference is significant 4 : 1 and 5 : 1 respectively.

Yield Tests. Ilorin Native *versus* Ishan A and B. Tables 9, 10, 11, 12.

These tests were carried out on B 29–40, B 41–60, E 29–44 and G 80–100. On G 80–100 cotton was grown as a sole crop, while on B 29–40 and B 41–60 through yams, and through groundnuts on E 29–44. The yields of cotton on the farm this year were below average for Ilorin plantation. There was no serious incidence of any pest or disease, but the plants as a whole with the exception of B 29–40, were small and rather stunted, possibly due in some measure, to the lack of regular rains during the early part of the growing season. The Ishan cottons suffered less from diseases and gave a harvest of cleaner seed-cotton. This has also occurred in previous years. When grown alone or through groundnuts, Ishan A gave practically the same yield as Ilorin native cotton, and was thus much more profitable because of its higher value per pound. When grown through yams the Ishan A yielded forty-two lb per acre less than the native cotton in one experiment, and fifty-seven lb less per acre in the other. But its higher value per pound of seed cotton compensates for this lesser yield to such an extent that it is actually more profitable by about 14s. per acre in the first of these two experiments, while in the second of them, the monetary return per acre was exactly the same. Thus on the whole Ishan A has been the more profitable cotton this year. In previous years the results have been similar. The Ishan B proved inferior in yield to Ishan A on the whole.

Yield Test on G 80–100 Ilorin *versus* Ishan A and B. Table 9.

The cotton on this block was grown as a sole crop and the results are as under.

Average of eleven plots of Ilorin 148 lb seed cotton per acre.
Average difference of five plots Ishan A -12 ± 19.
Average difference of five plots Ishan B -48 ± 19.
Percentage of dirty cotton. Ilorin 16·8, Ishan A 10·0, Ishan B 9·6.

Yield Test on B 29–40, Ilorin *versus* Ishan A. Table 10.

The cotton in this instance was grown through a crop of yams which is the usual practice on native farms in this district.

Average yield of six plots Ilorin ... = 365 lb seed cotton per acre.
Average difference of five plots Ishan A $= -42 \pm 34$.
Percentage of dirty cotton. Ilorin 16·8, Ishan A 7·6.

YIELD TEST ON B 41–60, ILORIN *versus* ISHAN A AND B. TABLE 11.

This block was also under yams through which the cotton was grown.

Average of nine plots Ilorin ... ... = 195 lb seed cotton per acre.

Average difference of four plots Ishan A = − 57 ± 27.

Average difference of four plots Ishan B = − 32 ± 27.

Percentage of dirty cotton. Ilorin 7·2, Ishan A 3·5, Ishan B 3·6.

YIELD TEST ON E 29–44. ILORIN *versus* ISHAN A AND B. TABLE 12

The cotton in this test was grown through a crop of groundnuts.

Average of eight plots Ilorin ... ... = 202 lb seed cotton per acre.

Average difference of four plots Ishan A = − 4 ± 20.

Average difference of three plots Ishan B = − 54 ± 23.

Percentage of dirty cotton. Ilorin 18·5, Ishan A 12·0, Ishan B 10·0.

LIMES.

The yields from the two one acre plots of limes this season have been some of the heaviest recorded, the total yield being :—

	Plots 21–24 one acre.	Plots 25–28 one acre.
1924	26,235 lb.	6,982 lb.
1925	34,200 „	23,362 „
1926	14,534 „	17,742 „
1927	11,914 „	11,073 „
1928	25,998 „	16,083 „

COCONUTS.

Five palms are bearing fruit this season, but in no great quantity, many nuts falling before maturing.

The crop cannot be considered a success under the conditions obtaining at Ilorin.

ORCHARD.

Oranges and tangerines yielded well, but the grape fruit was distinctly below average, these trees having given a heavy crop last season.

Rice.

Multiplication plots of varieties guiana creole, guiana seventy-five and maliya were continued, and seed distributed for trial in various districts.

The yields of dry unhusked grain per acre were as follows :—

Guiana Creole	...	...	1,900 lb. per acre.
Guiana seventy-five	...		1,442 „ „ „
Maliya	...	...	1,380 „ „ „

TABLE No. 1.

Meteorological Report for 1928.

Ilorin Farm Station.

Hour of observation, 9 a.m.

Months.	AIR TEMPERATURE.							Relative humidity Sat. 100.	1928 rainfall in inches.	No. of days.	Average rainfall for 24 years.
	Means.		Range.	Absolute.							
	Max.	Min.		Max.	Date.	Min.	Date.				
January	93°	60°	33°	98°	24th ...	50°	23rd ...	69	1·62	2	0·18
February ...	93°	61°	32°	99°	23rd ...	50°	7th ...	66	...	...	0·78
March	96°	67°	29°	99°	15th ...	64°	16th ...	71	5·99	6	1·95
April	91°	66°	25°	95°	22nd ...	63°	21st ...	60	3·92	5	4·59
May	88°	62°	26°	90°	8th ...	61°	20th ...	61	12·48	13	6·96
June	83°	64°	19°	86°	16th ...	62°	10th ...	72	4·92	11	7·22
July	81°	63°	18°	85°	23rd ...	60°	13th ...	78	6·23	9	5·81
August	80°	63°	17°	84°	15th ...	60°	15th ...	78	7·88	13	4·81
September ...	82°	63°	19°	85°	23rd ...	60°	29th ...	78	6·99	15	10·15
October	84°	63°	21°	88°	30th ...	60°	4th ...	71	7·36	14	6·55
November ...	88°	61°	27°	90°	16th ...	52°	29th ...	67	1·58	4	1·43
December ...	91°	55°	36°	95°	27th ...	45°	21st ...	63	...	...	0·37
Total ...	...	...	...	...	...	...	...	...	58·97	92	50·80
Means ...	87·5°	62·3°	25·2°	91·17°	...	57·25°	...	69·5	...	...	...

TABLE No. 2.

Groundnut Variety Test (Good Soil) with Interplanted Guinea-corn.

Plot F.	Variety.	Dry unshelled nuts per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.	Guinea-corn yields dry grain per acre in lb.	
26	Ilorin	824			602	
27	Chinese ...		820	− 164		778
28	Ilorin	1,144			706	
29	Chinese ...		908	− 256		749
30	Ilorin	1,184			801	
31	Chinese ...		1,028	− 140		713
32	Ilorin	1,152			638	
33	Chinese ...		1,116	− 62		665
34	Ilorin	1,204			721	
35	Chinese ...		1,252	− 48		672
36	Ilorin	1,396			739	
37	Chinese ...		1,168	− 300		778
38	Ilorin	1,540			682	
39	Ilorin					
	(Non-experimental) ...	1,312			719	

Groundnuts.

Average yield of control plots = 1,206 lb. dry unshelled nuts per acre.

Root—mean—square difference between adjacent controls = 166 lb. per acre.

Average difference of 6 plots Chinese variety − 161 ± 68.

Odds that the difference is significant. 121 : 1.

Plots $\frac{1}{4}$ acre, ridges 6′ apart, stands $1\frac{1}{2}$′ apart in double rows per ridge. Seed sown 3″ deep on April 16th.

Chinese nuts lifted September 5th. Ilorin nuts lifted September 22nd.

Cost of cultivation in man-days per acre, 91·2

Percentage decorticated to undecorticated = Ilorin 60%, Chinese 60·5%.

Guinea-corn.

Variety, Ilorin.

Sown June 16th in furrows, stands 2′ apart, two plants per stand.

Harvested January 4th, 1929.

Average yield of dry grain per acre in lb. = 712.

Percentage dry grain to grain on stalk as harvested = 72%.

Cost of cultivation in man-days per acre = 30·7.

TABLE No. 3.

Groundnuts Variety Test (Poor Soil) with Interplanted Guinea-corn.

Plot H.	Variety.	Dry unshelled nuts per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.	Guinea-corn in lb. of dry grain per acre.
1	Ilorin	872		333
2	Chinese	772	− 138	364
3	Ilorin	948		300
4	Chinese	744	− 136	347
5	Ilorin	812		275
6	Chinese	632	− 138	315
7	Ilorin	728		189
8	Chinese	664	− 72	305
9	Ilorin	744		275
10	Chinese	724	− 24	358
11	Ilorin	772		215
12	Chinese	620	− 150	319
13	Ilorin	788		261
14	Chinese	660	− 102	372
15	Ilorin	736		244
16	Chinese	728	− 48	247
17	Ilorin	816		239
18	Chinese	780	− 30	318
19	Ilorin	804		140
20	Chinese	636	− 166	213
21	Ilorin	800		180
22	Chinese	624	− 158	309
23	Ilorin	764		248

Groundnuts.

Average yield of Ilorin variety of 12 plots = 797 lb. dry unshelled nuts per acre.

Root—mean—square—difference between adjacent controls, 63 lb. per acre.

Average difference of 11 plots, Chinese variety = − 106 ± 19 lb. per acre.

Odds that difference is significant over 1,000 : 1.

Plots ¼ acre, ridges 6′ apart, stands 1½′ apart in double rows.

Seed sown 3″ deep on April 17th.

Chinese nuts harvested September 18th.

Ilorin nuts harvested September 29th.

Cost of cultivation in man-days per acre, 59·6.

Percentage decorticated to undecorticated Ilorin, 56%, Chinese 54%.

Guinea-corn.

Variety, Ilorin sown June 14th in furrows. Harvested December 31st.

Stands 2′ apart, 16 stands per furrow, 2 plants per stand.

Average yield dry grain per acre = 287.

Percentage dry grain to grain on stalk = 66%.

Cost of cultivation in man-days per acre = 27·4.

TABLE No. 4.

Ground Nuts.

Stale Ridges *versus* New Ridges.

Block A.	Treatment.	Yields in dry unshelled nuts per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
61	Old ridges	864	
62	New ridges	988	+ 8
63	Old ridges	1,096	
64	New ridges	1,104	+ 22
65	Old ridges	1,068	
66	New ridges	1,080	− 10
67	Old ridges	1,112	
68	New ridges	1,248	+ 142
69	Old ridges	1,100	
70	New ridges	1,208	+ 92
71	Old ridges	1,132	
72	New ridges	1,192	+ 98
73	Old ridges	1,056	
74	New ridges	1,128	+ 72
75	Old ridges	1,056	
76	New ridges	1,188	+ 98
77	Old ridges	1,124	
78	New ridges	1,208	+ 104
79	Old ridges	1,084	
80	New ridges	1,164	+ 44
81	Old ridges	1,156	

Average of 11 plots on old ridges = 1,077 lb. per acre of dry unshelled nuts.

Average difference of 10 plots on new ridges = + 67 ± 27 lb. per acre of dry unshelled nuts.

Root—mean—square—difference between neighbouring controls = 86.

Odds that the difference is significant 160 : 1.

Plots ¼ acre, ridges 6′ apart, stands 1½′ in double rows per ridge.

Seed sown 3″ deep on April 30th.

Harvested October 13th to 23rd.

Cost of cultivation in man-days per acre = 55·2.

Percentage decorticated to undecorticated nuts 62%.

TABLE No. 5.

Groundnuts *var.* Chinese Guinea-Corn Inter-Planted.

One Row per Ridge *versus* Two Rows per Ridge.

Block G.	Treatment.	Dry unshelled nuts per acre in lb.	Increase (+) or decrease (−) compared with mean of adjacent controls.	Guinea-corn yields in lb. dry grain per acre.
36	Two rows ...	452*		248
37	One row ...	472	− 81*	327
38	Two rows ...	654		406
39	One row ...	518	−143	547
40	Two rows ...	668		526
41	One row ...	498	−168	531
42	Two rows ...	664		500
43	One row ...	534	− 98	516
44	Two rows ...	600		338
45	One row ...	404	−200	346
46	Two rows ...	608		393
47	One row ...	476	−171	462
48	Two rows ...	686		510
49	One row ...	494	−206	509
50	Two rows ...	714		435
51	One row ...	488	−193	471
52	Two rows ...	648		433
53	One row ...	552	−116	418
54	Two rows ...	688		528
55	One row ...	476	−208	557
56	Two rows ...	680		436
57	One row ...	462	−188	441
58	Two rows ...	620		433
59	One row ...	412	−149*	433
60	Two rows ...	502*		422

* Figures omitted owing to abnormal soil difference between plots 36, 37, 38, and 58, 59, 60.

Groundnuts.—Var : Chinese throughout.

Average yield of 11 control plots, 2 rows per ridge = 657 lb.

Root—mean—square—difference of adjacent controls = 46 lb. per acre.

Average difference of 10 rows of one per ridge = −169 ± 14·5 lb. per acre.

Odds that the difference is significant, over 10,000 : 1

Plots, ¼ acre ridges 6 ′ apart, stands 1½ ′ apart.

Seed sown May 2nd, nuts harvested October 2nd.

Cost of cultivation in man-days per acre 56·2.

Percentage decorticated to undecorticated nuts = 62 %.

Guinea-corn.—Var. Ilorin.

Sown June 17th in furrows, stands 2 ′ apart, 16 stands per furrow, 2 plants per stand Harvested January 2nd, 1929.

Average yield of dry grain per acre = 447 lb.

Percentage dry grain to grain on stalk = 72 %.

Cost of cultivation in man-days per acre = 23·2.

Harvested January 2nd, 1929.

TABLE No. 6.

Maize and Guinea-corn.

Test Crops Following Mucuna in Alternate Plots.

Block D.	Treatment.	Maize dry grain per acre in lb.	Guinea-corn in lb. of dry grain per acre.	Combined Crop.	Increase (+) or decrease (−) compared with mean of adjacent controls.
29	Mucuna	620	633	1,253	
30	No Mucuna	468	461	92	− 396
31	Mucuna	708	690	1,398	
32	No Mucuna	488	541	1,029	− 359
33	Mucuna	704	675	1,379	
34	No Mucuna	396	441	837	− 524
35	Mucuna	668	676	1,344	
36	No Mucuna	476	418	894	− 367
37	Mucuna	604	574	1,178	

Maize.—Average yield of control plots = 661 lb. dry grain per acre. Sown May 22nd one row per ridge, stands 2′ apart, 2 plants per stand.
Harvested September 10th. Percentage dry grain to grain on cob = 58%.
Cost of cultivation = 48·3 man-days per acre.

Guinea-corn.—Average yield of control plots = 649 lb. dry grain per acre. Sown June 21st in furrows 2′ apart, 2 plants to a stand.
Harvested January 4th and 5th. Percentage dry grain to grain on stalk = 70%
Cost of cultivation in man-days per acre = 30·3.
Average yield of combined grain from 5 plots with Mucuna = 1,310 lb. per acre.
Average difference from 4 plots with no Mucuna = −412±56.
Root–mean–square–difference of adjacent controls = 112.
Odds that the difference is significant = over 1,000 : 1.

TABLE No. 7.

Maize.

Test Crop after Mucuna on Alternate Plots.

Block E2.	Treatment.	Maize—dry grain in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
1	Mucuna	752	
2	No Mucuna	692	− 144
3	Mucuna	920	
4	No Mucuna	620	− 268
5	Mucuna	856	
6	No Mucuna	628	− 172
7	Mucuna	744	
8	No Mucuna	512	− 204
9	Mucuna	688	

Average yield of 5 control plots with Mucuna = 792 lb. per acre.
Average difference of 4 plots with no Mucuna = −197 ± 55 lb. per acre.
Root—mean—square—difference between adjacent controls = 110 lb. per acre.
Size of plots ¼ acre, ridges 6′ apart.
Maize sown May 10th one row per ridge, stands 2′ apart 2 plants per stand.
Harvested September 3rd.
Percentage dry grain on cob. = after Mucuna 67%, after no Mucuna = 68%
Cost of cultivation in man-days per acre = 49·6.
Odds that the difference is significant over 1,000 : 1.

TABLE No. 8.

Cotton—Spacing Test.

Block C.	Yield of Yams in lb. per acre.	Yield of Seed Cotton lb. per acre.	Planting distance.	Increase (+) or decrease (−) compared with mean of adjacent controls. At 1½′	At 2½′
41	8,704	296	2′		
42	8,192	224	1½′	− 16	
43	7,176	184	2′		
44	8,288	164	2½′		− 30
45	8,960	204	2′		
46	8,064	236	1½′	+ 28	
47	7,864	212	2′		
48	8,112	180	2½′		− 14
49	8,232	176	2′		
50	7,392	132	1½′	− 60	
51	8,064	208	2′		
52	7,280	160	2½′		− 22
53	6,828	156	2′		
54	7,056	140	1½′	− 18	
55	7,324	160	2′		
56	7,280	148	2½		− 24
57	7,812	184	2′		
58	7,280	140	1½′	− 18	
59	7,084	132	2′		

Average of 9 plots planted at 2′ intervals = 191 lb. per acre.

Average difference of 5 plots planted at 1½′ = − 17 ± 22 lb. p. a.

Average difference of 4 plots planted at 2½′ = − 23 ± 25 „ „ „

Root—mean—square—difference between neighbouring controls = 49.

Odds that the difference is significant, 4 : 1 and 5 : 1 respectively.

¼ acre plots.

Yams. Ridges 6 feet apart, yams planted at 2½′ intervals on December 14th, 1927. Variety Boki.

Cotton. Variety Ishan A 27 sown through yams on July 9th and harvested on January 3rd & January 18th, February 14th & February 26th.

Cost of cultivation in man-days per acre.

Combined crop = 149 man-days per acre.

Cotton alone = 54 „ „ „

TABLE No 9.

YIELD TEST OF ILORIN *versus* ISHAN A AND B.

(Cotton as sole crop.)

Block G Plot.	Variety.	Yield in lb. per acre Seed Cotton.	Increase (+) or decrease (−) compared with mean of adjacent controls.	
			Ishan A	Ishan B.
80	Ilorin	100		
81	Ishan A	128	+ 10	
82	Ilorin	136		
83	Ishan B	100		— 54
84	Ilorin	172		
85	Ishan A	148	+ 2	
86	Ilorin	120		
87	Ishan B	92		— 38
88	Ilorin	140		
89	Ishan A	164	+ 4	
90	Ilorin	180		
91	Ishan B	160		— 12
92	Ilorin	164		
93	Ishan A	136	— 18	
94	Ilorin	144		
95	Ishan B	88		— 88
96	Ilorin	208		
97	Ishan A	124	— 60	
98	Ilorin	160		
99	Ishan B	84		— 48
100	Ilorin	104		

Average of 11 plots of Ilorin = 148 lb. per acre.

Average difference of 5 plots Ishan A = − 12 ± 19.

Average difference of 5 plots Ishan B = − 48 ± 19.

Root—mean—square—difference between neighbouring controls = 42.

Odds that difference is significant 3 : 1 and 160 : 1 respectively.

¼ acre plots.

Cotton planted 2′ apart on 6′ ridges on July 13th and harvested on January 2nd, 17th, February 5th, 22nd & March 18th.

Cost of cultivation in man-days per acre = 81.

TABLE 10.

Yield Test of Ilorin *versus* Ishan A.

(Cotton through Yams).

Block B Plot.	Yield of Yams in lb. per acre.	Variety of Cotton.	Yield of Seed Cotton in lb. per acre.	Increase (+) or decrease ( )compared with mean of adjacent controls.
29	14,104	Non-Experimental		
30	14,336	Ilorin	296	
31	14,336	Ishan A ...	292	— 20
32	13,664	Ilorin	328	
33	14,112	Ishan A. ...	324	— 64
34	14,560	Ilorin	448	
35	14,336	Ishan A ...	428	— 22
36	15,008	Ilorin	452	
37	15,792	Ishan A ...	324	— 92
38	15,008	Ilorin	380	
39	15,008	Ishan A ...	320	— 12
40	12,544	Ilorin	284	

$\frac{1}{4}$ acre plots.

Average yield of 6 plots of Ilorin ... = 365 lb. per acre.

„ difference of 5 plots of Ishan A. = -42 ± 34.

Root—mean—square—difference between neighbouring controls = 77.

Odds that the difference is significant 8 : 1.

Yams.—Planted on 6′ ridges at 2′ 6″ intervals. Var. Boki harvested on November 17th.

Cotton.—Sown on July 16th at 2′ intervals on side of ridges, and harvested on January 4th and 19th; February 11th and 23rd; March 11th and 20th.

Cost of crop in man-days per acre. = Combined crop = 153.
Cotton alone = 67·7.

TABLE No. 11.

Yield Test of Ilorin *versus* Ishan A. and B.

(Cotton through Yams).

Block B Plot.	Yield of Yams in lb. per acre.	Variety of Cotton.	Yield of Seed Cotton in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.	
				Ishan A.	Ishan B.
41	12,220	Ilorin	360		
42	15,048	Ishan A ...	256	− 44	
43	10,880	Ilorin	240		
44	10,872	Ishan B ...	148		− 72
45	10,760	Ilorin	200		
46	8,540	Ishan A ...	92	− 78	
47	8,200	Ilorin	140		
48	8,748	Ishan B ...	124		− 28
49	9,104	Ilorin	164		
50	9,100	Ishan A ...	136	− 44	
51	9,908	Ilorin	196		
52	9,984	Ishan B ...	132		− 42
53	7,832	Ilorin	152		
54	8,296	Ishan A ...	88	− 60	
55	9,800	Ilorin	144		
56	10,340	Ishan B ...	164		+ 14
57	11,216	Ilorin	156		
58	10,196	Non-Experimental			
59	9,496	„ „			
60	7,528	„ „			

$\frac{1}{4}$ acre, plots.

Average yield of 9 plots Ilorin ... ... = 195 lb. per acre.

„ difference of 4 plots Ishan A = − 57 ± 27.

„ „ „ 4 „ „ B = − 32 ± 27.

Odds that the difference is significant 55 : 1 and 7 : 1 respectively.

Root—mean—square difference of neighbouring controls = 54.

Yams.—Planted on 6′ ridges at 2′ 6″ intervals. Var. Boki; harvested on November 22nd.

Cotton.—Sown on July 5th at 2′ intervals on side of ridges, and harvested on January 4th and 21st; February 8th and 25th; March 23rd.

Cost of cultivation in man-days per acre. Combined crop = 141·6.

Cotton alone = 60.

TABLE No. 12.

YIELD TEST OF ILORIN *versus* ISHAN A. AND B.

(Through Groundnuts).

Block E Plot.	Yield of Groundnuts in lb. per acre.	Variety of Cotton.	Yield of Cotton in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.	
				Ishan A.	Ishan B.
29	872	Ilorin			
30	896	Ishan A ...	200		
31	924	Ilorin	236	+ 14	
32	992	Ishan B ...	244		
33	1,008	Ilorin	172		− 90
34	904	Ishan A ...	280		
35	1,152	Ilorin	228	− 20	
36	965	Ishan B ...	216		
37	1,008	Ilorin	140		− 76
38	968	Ishan A ...	216		
39	1,016	Ilorin	176	− 12	
40	1,072	Ishan B ...	160		
41	944	Ilorin	164		+ 4
42	904	Ishan A ...	160		
43	1,056	Ilorin	156	+ 4	
44	716	Non-Experimental	144		

$\frac{1}{4}$ acre plots.

Average of 8 plots of Ilorin ... ... = 202 lb. per acre.

„ difference of 4 plots Ishan A = − 4 ± 20.

„ „ „ 3 „ „ B = − 54 ± 23.

Odds that the difference is significant 2 : 1 and 121 : 1.

Root-mean-square difference between neighbouring controls = 39.

Groundnuts.—Planted in two rows stands 18″ apart on 6 ft. ridges on April 28th and harvested on October 13th. Var. Chinese.

Cotton.—Planted on subsidiary ridges between ridges of groundnuts stands 2′ 6″ apart and moulded up after groundnuts harvested. Planted on July 9th and harvested December 31st, January 22nd, February 6th and 26th, March 18th.

Cost of crop in man-days per acre;—Combined crop = 119·7.
Cotton alone = 40·5.

SAMURU STATION.

Mr. O. S. Swainson was in charge of this Station throughout the year.

Mixed Farming :—Experiments in mixed farming have now reached a practical stage, and during the year under review, thirty-two acres on the Samuru farm have been cultivated practically entirely by cattle-drawn implements.

Valuable information has been gained as to the present and probable difficulties of this form of farming, and in 1929 some 100 further acres will be tilled in the same way.

Implements :—Great improvements have been made in the design of the locally-made wooden ploughs, and the wastage of timber caused by cutting them out of one block of wood has been obviated by making the sole and mouldboards separately, and then fastening them together by simple methods.

Several fresh ideas have been gained by the study of two imported wooden Egyptian ploughs.

Maintenance of Fertility under mixed farming Conditions :—In the course of experiments at Samuru it has been found that four adult cattle, (which are equivalent to the average number of beasts, including young stock, which a farmer might be expected to own), will make over eight and half tons of farm-yard manure in a year.

If this were yearly applied to half a ten acre farm it would mean a dressing of about $1\frac{3}{4}$ tons per acre over the whole farm every other year, which although by English standards is small, has previously given almost unbelievably good results in Northern Nigeria.

With the assistance of an occasional leguminous crop it may well be found possible to maintain fertility indefinitely, and if this proves to be the case the problem of shifting cultivation will be practically solved.

Cattle Cultivation on Native Owned Farms :—Considerable interest has been evinced by the local population in the possibilities of these changed methods, and towards the end of the rains two farmers were sufficiently impressed to take over cattle and implements for themselves.

At present it is sufficient to say that the prospects of their making a success of the venture are good.

Rainfall and Weather :– The year was characterised by exceptionally good early rains, notably in May and June, and unusually light mid-season rains, especially in August. (*See* Table No. 1). This resulted in water logging, which is usually severe on portions of the farm, being almost entirely absent, and had the late rains been rather better record crops might have resulted.

In actual fact though guinea-corn was well up to average, cotton was very disappointing, the effect of the light late rains being accentuated by an early spell of harmattan and unusually severe boll worm attacks, with the result that the season's yields are about the lowest on record.

Imported Beans :—The small white Lima bean (P. lunatus), has unfortunately again proved a failure when interplanted, as it seems unable to bear shade, but several other species of bean are now being tested.

Of these, which were grown as straight crops, the Soyas (Glycuri hispida), semi bush cow-peas (Vigna Catjang), and Bush Lima and Madagascar beans (Phaseoli Var.), are the most promising ; but they will be tried on a more extensive scale, and as interplanted crops, during the coming year.

Farm-yard Manure on Cotton Experiment :—(*See* Table No. 2). This is being conducted on the same plots as the old early green manure experiment, which was discontinued owing to the impossibility of growing a sufficient bulk of mucuna before ridging for cotton.

It is intended to test whether the fertility of soil for cotton growing can be maintained by an annual dressing of two tons farm-yard manure per acre.

	Pounds seed cotton per acre.	Odds that difference is significant.
Average yield of 7 plots without manure	314	—
Average difference of 6 plots with manure as compared with those without manure	+ 19 ± 31	—

Exhaustibility of crops Experiments (*A*) :—(*See* Tables Nos. 3 and 4). These were concluded during the year under review, but have not yielded any very striking or conclusive results.

As was to be expected groundnuts are the least exhausting crop, and cotton apparently less so than guinea-corn or maize.

Guinea-corn does best when sown after cotton, and cotton yields well after any crop except itself.

The results were however in no case significant and it is intended to repeat the experiment elsewhere with a greater number of treatments, and omitting maize which grows unsatisfactorily under local conditions.

	Yield of seed cotton in lb. per acre.		Odds that difference is significant.	
	A 14–26 1926.	A 27–39 1928	A 14–26 1926	A 27–39 1928
Average yield of cotton on 7 plots following groundnuts	291	265	—	—
Average difference of cotton yields on 2 plots following maize	−25±69	− 8±71	—	—
Average difference of cotton yields on 2 plots following guinea-corn	+15±69	−26 ±71	—	—
Average difference of cotton yields on 2 plots following cotton	−15±69	− 65±71	—	5 : 1

	Yield of guinea-corn heads in lb. per acre. A 27–39 1926	Yield of threshed guinea-corn in lb. per acre. A 14–26 1928	Odds that difference is significant. A 27–39 1926	A 14–26 1928
Average yield of guinea-corn on 7 plots following groundnuts	1,044	955	—	—
Average difference of guinea-corn yields on 2 plots following maize	− 278 ± 300	− 53 ± 179	5 : 1	—
Average difference of guinea-corn yields on 2 plots following guinea-corn ...	− 301 ± 300	− 185 ± 179	5 : 1	6 : 1
Average difference of guinea-corn yields on 2 plots following cotton	− 50 ± 300	− 42 ± 179	—	—

A number of minor experiments were carried out to ascertain the best methods of interplanting cow-peas and other edible legumes with the guinea-corn crop. The results of these were not very decisive.

Phosphate Test. Superphosphate v. Nigerian Rock Phosphate:- (*See* Table No. 5). The land was not redressed with manure and guinea-corn was planted to test the residual effects. It will be seen that the superphosphate remaining still slightly, but not significantly, outweighs any rock phosphate which may have become available.

	Lb. of threshed grain per acre.	Odds that difference is significant.
Average yield of 10 plots receiving 200 lb. Nigerian rock phosphate per acre ...	820	—
Average difference of 9 plots receiving 220 lb. super phosphate per acre ...	+ 52 ∓ 71	3 : 1

Manurial Experiment :—(*See* Table No. 6). The order of the results this year, although they are not significant, are almost exactly the same as those last season, with the exception of the fact that the sulphate of ammonia seems to have no residual effect.

The Nigerian rock phosphate is obviously slowly becoming available and has had much more residual value than the farm-yard manure. Yields were very much lower on all plots.

	Threshed corn per acre.		Odds that difference is significant.	
	1927	1928	1927	1928
Average yields of 17 plots receiving 3 tons farm yard manure per acre	1,553	862	—	—
Average difference of 4 plots receiving 200 lb. Nigerian rock phosphate per acre ...	— 363 ∓ 90	+ 45 ∓ 117	33,000 : 1	—
Average difference of 4 plots receiving 200 lb. Nigerian rock phosphate and 75 lb. sulphate of ammonia per acre	— 135 ∓ 104	+ 16 ∓ 135	9 : 1	—
Average difference of 4 plots receiving 3 tons farm yard manure and 200 lb. Nigerian rock phosphate per acre ...	+ 210 ∓ 104	+ 88 ∓ 135	43 : 1	3 : 1
Average difference of 4 plots receiving no manure ...	— 776 ∓ 104	—265 ∓ 135	∝ : 1	42 : 1
Average difference of 4 plots receiving 200 lb. Nigerian rock phosphate and 60 lb. muriate of potash per acre	— 450 ∓ 104	— 109 ∓ 135	∝ : 1	4 :

Cattle Cultivation. Cotton Spacing Experiment :—(*See* Table No. 7). The yields from this block compared very satisfactorily with those from hand cultivated areas on the farm, especially as previously this land was very waterlogged and seldom produced good crops.

	Lb. of seed cotton per acre.	Odds that difference is significant.
Average yields of 17 plots spaced at 1½′	279	—
Average difference of 8 plots spaced at 2′	— 6 ∓ 32	—
Average difference of 7 plots spaced at 1′	+ 21 ∓ 34	3 : 1

Cattle Cultivation. Guinea-corn Spacing Experiment :—(*See* Table No. 8). The guinea-corn was planted rather late and yields were only fair. A certain amount of trouble from lodging due to wash and to inadequate ridges, was experienced, but this should be remedied in the forthcoming year.

The interplanted cow-peas yielded at the rate of about thirty lb. per acre of threshed beans and 241 lb. of haulm.

	Lb. per acre of threshed grain.	Odds that difference is significant.
Average yields of 17 plots of guinea-corn spaced at 5′	694	—
Average difference of 8 plots spaced at 4′	+ 62 ∓ 35	23 : 1
Average difference of 7 plots spaced at 6′	− 5 ∓ 38	—

Fodder Crop Experiment :—(*See* Table Nos. 9 and 10). This was brought to a close this year with testing crops of gero and guinea-corn, which had their yields combined in working out the result in order to avoid any "weighting" of individual plots of the latter crop by poor crops or otherwise of the former; and also to indicate the gross productive powers of the plots.

The cropping has been as follows :—

	Year I.	Year II.	Year III.
Standards ...	Gero and Guinea-corn ...	Guinea-corn ...	Gero–Guinea-corn
Treatment B ...	Gero Mucuna (removed and F.Y.M. equivalent returned)	,, ...	,, ,,
,, C ...	Gero Mucuna (removed entirely)	,, ...	,, ,,
,, D ...	Gero Mucuna (turned in for green manure) ...	,, ...	,, ,,
,, E ...	Gero Mucuna (folded off by cattle)	,, ...	,, ,,

	1927 Lb. corn per acre on hand.	1927 Odds that difference is significant.	1928 Lb. per acre on head.	1928 Odds that difference is significant.
Average of 17 plots of guinea-corn gero after gero guinea-corn	687	—	1,049	—
Average difference of 4 plots guinea-corn gero after treatment B	+ 365∓98	15,000 : 1	+82∓383	—
Average difference of 4 plots guinea-corn gero after treatment C	+ 205∓98	50 : 1	+120∓383	—
Average difference of 4 plots guinea-corn gero after treatment D	+ 521∓98	0 : 1	+203∓383	—
Average difference of 4 plots guinea-corn gero after treatment E	+ 174∓98	15 : 1	+221∓383	3 : 1

On examination of Table No. 13A it will be seen that except in the case of the plots where the mucuna was turned in for green manure the corn lost by omitting guinea-corn and growing mucuna instead on the first year has not been recovered.

While this is a most satisfactory result in that it proves the efficacy of green manuring it is disappointing as it appears that the growing of fodder crops is likely to lead to a loss in the money and food crop of corn produced.

It is intended to investigate this problem further.

Cattle Cultivation. Groundnut Spacing Experiment :—(*See* Table No. 4). The yields on this block, though low, compare satisfactorily with those on hand cultivated land on other parts of the farm.

Difficulty was experienced in late hoeing and ridging without disturbing the nuts, and wash proved troublesome in the S.E. of the block.

Bunching was present but not to any unusual extent.

	Lb. of threshed nuts per acre.	Odds that difference is significant
Average of 17 plots of groundnuts spaced at 2′	450	—
Average difference 8 plots of groundnuts spaced at 1½′	+ 30 ∓ 24	8 : 1
Average difference 7 plots of groundnuts spaced at 1′	+ 80 ∓ 26	700 : 1

The block also yielded an average of 619 lb. groundnut haulms per acre.

Cattle Cultivation. Gero Spacing Experiment with Interplanted Mucuna :—(*See* Tables Nos. 12 and 13). This was intended to ascertain how heavy a corn crop could be grown without seriously reducing the interplanted fodder (mucuna) crop.

Taking into consideration the abnormally late date of planting, the gero crop was good. The mucuna grew slowly at first, but after cutting the gero, went ahead fast, climbing on the gero stalks, and ultimately yielded satisfactorily.

"Wash" was the chief trouble on this block, which is sandy.

	Lb. of grain per acre.	Odds that difference is significant.
Average yield per acre of 17 plots gero at 9 rows per plot	364	—
Average difference of 8 plots of gero at 11 rows per plot	− 9 + 32	—
Average difference of 9 plots of gero at 7 rows per plot	− 65 ∓ 32	35 : 1
	Lb. of one day dried hay per acre.	Odds that difference is significant.
Average yield per acre of 17 plots Mucuna in 9 rows gero	1,631	—
Average difference of 8 plots Mucuna in 11 rows gero	+ 21 ∓ 123	—
Average difference of 7 plots Mucuna in 7 rows gero	− 150 ∓ 131	4 : 1

It will be seen from the above tables that nine rows is the most economical planting distance for gero : and that the mucuna actually does better in the more thickly planted gero through having the stalks on which to climb.

Guinea-corn. Size of ridges Experiment :—(See Table No. 14). This demonstrates that under normal conditions there is apparently some loss of grain entailed when guinea-corn is planted on two feet six inches ridges. Further investigation will be made next year.

	Lb. of threshed grain per acre.	Odds that difference is significant.
Average yield of 9 plots guinea-corn on 4′ ridges	953	—
Average difference of 8 plots guinea-corn on 2′ 6″ ridges	−118∓50	510 : 1

Cotton. Size of ridges Experiment :—(See Table No. 15). The cotton on the two feet six inches ridges made noticeably stronger vegetative growth than that on the four feet ridges. Little difference was noted in the number or size of bolls.

Neither the size of the ridges nor the number of plants per acre appear to affect the yield to any significant extent.

	Lb. of seed cotton per acre.	Odds that difference is significant.
Average yield of 9 plots cotton 4′ ridges with plants spaced 1′ 3″	209	—
Average difference of 4 plots cotton on 2′ 6″ ridges with plants spaced 2′ ...	− 3∓41	—
Average difference of 4 plots cotton on 2′ 6″ ridges with plants spaced 1′ 3″ ...	− 32∓41	4 : 1

Farm-yard Manure v. Kraaling Experiment :—(See Table No. 16). The following weights of farm-yard manure per acre were applied to the treatment plots.

	1928.	1926 Rates.
100 Cattle Nights ...	1,134 lb.	3,360 lb.
200 „ „ ...	2,268 „	6,720 „
300 „ „ ...	3,402 „	10,080 „
400 „ „ ...	4,536 „	13,440 „

1,134 lb. is the actual amount of manure produced in a pen by one beast in 100 nights. The 1926 rates are misleading owing to the manure containing an excess of water and bedding.

The result of the experiment approximates to that of the two previous years except that the farm-yard manure does not show such a marked superiority.

	Seed-Cotton in lb. per acre.	Odds that difference is significant.
Average yield of 17 plots with 400 Cattle Nights Kraaling	329	—
Average difference in yield of 4 plots with 100 Cattle Nights Farm Yard Manure	− 50∓17	78,000 : 1
Average difference in yield of 4 plots with 200 Cattle Nights Farm Yard Manure	− 29∓17	22 : 1
Average difference in yield of 4 plots with 300 Cattle Nights Farm Yard Manure	+ 22∓17	9 : 1
Average difference in yield of 4 plots with 400 Cattle Nights Farm Yard Manure	+ 73∓17	33,300 : 1

Cotton Strain Test:—(*See* Table No. 17). The germination capacity of the Strain D and E seed was inferior to that of the Zaria ginnery seed, and this resulted in heavy supplying and the consequent lateness of a considerable percentage of the crop.

The standard plots and those planted with Strain D grew vigorously but Strain E was inferior in this respect.

Ginning Percentages.

	Lint.	Seed.	Waste.
Standard ...	29·48	69·56	·96
Strain "D" ...	31·07	67·66	1·27
Strain "E" ...	25·44	72·61	1·95

The above ginning percentages are included for comparison with the yields.

The lint from Strain D and E was longer and less harsh than that from the standards.

	Seed cotton in lb. per acre.	Odds that difference is significant.
Average yield of 17 plots, Zaria Ginnery Grade I Seed	277	—
Average difference 8 plots Strain D. ...	− 38∓25	15 : 1
Average difference 8 plots Strain E. ...	− 52+25	35 : 1

Cattle:—(*See* Table No. 18). On the whole the health of the Shuwa cattle at Samaru has remained good, the exception being the prevalence of Streptithricosis, (Hausa–Kirchi), during the rains. This has proved extremely difficult to eradicate, although spraying with an arsenical wash has been extensively practised.

In addition there was a serious outbreak of pleuro pneumonia among the working cattle, resulting in the loss of some dozen beasts, but owing to rigorous isolation the breeding herd was scarcely touched, and only one stock bull and one bull calf lost.

Fifteen calves were born during the year, of which thirteen are doing well, two having died after severe scouring which was diagnosed as a mild form of rinderpest.

Daily milk records have been kept throughout the year; so far yields have been rather poor but should increase with the general improvement in condition of the cattle.

Butter fat content has been high, varying from 5·5 to 6 *per cent.*, and a recent seven-day test with four cows gives the following figures.

No. of Cow.	Morning Butter Fat %	Evening Butter Fat %.	Average Daily Yield in lb.
16	6·25	6·35	14½
18	6·50	6·72	5
22	6·80	7·25	9½
26	5·81	6·14	13

In addition to a maintenance ration varying as to the time of the year a production ration of three and a half lb. concentrates per gallon of milk has been fed, composed as follows :—

Cotton Seed	6 parts.
Guinea-corn	2 ,,
Groundnuts	1 part.

No difficulty was experienced in training any of the working cattle to work either on the land or in carts.

Nursery and Garden :—An irrigated garden has been started in the fadama close to the nursery which has ensured a supply of vegetables to European Officers throughout the dry season.

A wet season vegetable garden is also maintained in the residential block.

Poultry :—Seven cockerels and one pullet have been sold during the year.

A total of 580 eggs have been produced and have mostly been sold for sitting.

TABLE No. 1.

RAINFALL—SAMARU, 1928.

Month.	Inches of rain.	Number of days on which rain fell.	Average rainfall at Samaru, 1924–27 inclusive.
January	0·02	3	...
February	...	...	...
March	2·07	4	0·80
April	2.21	4	1·44
May	7·17	15	3·68
June	9·66	13	7·39
July	9·28	20	10·27
August	8·95	20	12·19
September	8·54	14	9·07
October	1·80	6	2·28
November	...	...	·10
December	...	...	...
Totals	49·70	99	47·22

TABLE No. 2.

Farm Yard Manure on Cotton Experiment.

Plot.	Crop.	Treatment.	Pounds per acre of seed cotton. Control Plot 5.	Pounds per acre of seed cotton. Treatment Plot 5.	Increase (+) or decrease (−) from yields of adjacent control plots
A 1	Allen Cotton	No Manure	198		
2	,, ,,	·5 Tons		244	− 23
3	,, ,,	No Manure	336		
4	,, ,,	·5 Tons		387	+ 62
5	,, ,,	No Manure	314		
6	,, ,,	·5 Tons		283	− 35
7	,, ,,	No Manure	321		
8	,, ,,	·5 Tons		342	− 24
9	,, ,,	No Manure	410		
10	,, ,,	·5 Tons		446	+ 71
11	,, ,,	No Manure	340		
12	,, ,,	·5 Tons		372	+ 61
13	,, ,,	No Manure	282		
		Average ...	314		+ 19

Variety sown—Allen. 14th December, 1928.
Date sown. 29th June, 1928. Date of harvesting, 5th January, 1929; 1st and 21st February, 1929.
Each plot ¼ acre.
Average increase (+) or decrease (−) of yield of manured plots as compared with unmanured plots = + 19 ± 31·
Root—mean—square—difference between neighbouring control plots = 77·0.
Cost of cultivation in man-days per acre = 85·5.

TABLE No 3.

Exhaustibility of Crops Experiment A.

Plot.	Crop.	Treatment.	Pounds per acre of threshed corn. Control Plots.	Pounds per acre of threshed corn. Treatment Plots.	Increase (+) or decrease (−) from means of adjacent controls.
A 14	Guinea-corn after	Groundnuts ...	1,263		
15	,, ,,	Maize ...		1,008	− 68
16	,, ,,	Groundnuts ...	888		
17	,, ,,	Guinea-corn ...		810	− 223
18	,, ,,	Groundnuts ...	1,197		
19	,, ,,	Cotton ...		1,101	− 70
20	,, ,,	Groundnuts ...	945		
21	,, ,,	Maize ..		858	− 38
22	,, ,,	Groundnuts ...	846		
23	,, ,,	Guinea-corn ...		621	−138
24	,, ,,	Groundnuts ...	672		
25	,, ,,	Cotton ...		690	− 14
26	,, ,,	Groundnuts ...	576		
		Average ...	955		= 53 −185 = 42

Variety Sown :—Kaura.
Date of sowing. 2nd May, 1928. Date of harvesting, 24th November, 1928.
Each plot ¼ acre. All dressed with two tons Farm-yard Manure per acre. All in 6' ridges.
Average increase (+) or decrease ( ) of plots after maize compared with those after groundnuts = − 53 ± 179.
Average increase (+) or decrease (−) of plots after guinea-corn compared with those after groundnuts = − 185 ± 179.
Average increase (−) or decrease ( ) of plots after cotton compared with those after groundnuts = − 42 ± 179.
Root—mean—square—difference between neighbouring controls = 252.
Cost of cultivation in man-days per acre = 75·0.

TABLE No. 4.

Exhaustibility of Crops Experiment.

Plot.	Crop.	Treatment.	Yield in lb. per Acre of Seed Cotton.		Increase (+) or decrease (−) from means of adjacent controls.
			Control Plots.	Treatment Plots.	
A27	Cotton after	Groundnuts ...	289		
28	,, ,,	Maize ...		290	−15
29	,, ,,	Groundnuts ...	320		
30	,, ,,	Guinea-corn ...		249	−45
31	,, ,,	Groundnuts ...	269		
32	,, ,,	Cotton ...		126	−117
33	,, ,,	Groundnuts ...	216		
34	,, ,,	Maize ...		284	− 1
35	,, ,,	Groundnuts ...	354		
36	,, ,,	Guinea-corn ...		258	− 7
37	,, ,,	Groundnuts ...	175		
38	,, ,,	Cotton ...		191	− 12
39	,, ,,	Groundnuts ...	232		
		Average ...	265		− 8 −26 − 65

Variety grown Allen.

Date of sowing, 29th June, 1928. Date of harvesting, 3rd December, 1928,
4th January, 1929,
2nd February, 1929,
21st February, 1929.

Each plot ¼ acre. All dressed with 2 tons Farm-yard Manure per acre.

Average increase (+) or decrease (−)f yield of plots after maize as compared with those after groundnuts = − 8 ± 71.

Average increase (+) or decrease (−) of yield of plots after guinea-corn as compared with those after groundnuts = − 26 ± 71.

Average increase (+) or decrease (−) of yield of plots after cotton as compared with those after groundnuts = − 65 ± 71.

Root---mean—square—difference between neighbouring control plots = 100.

Cost of cultivation in man-days per acre, = 94.5.

TABLE No. 5.

Nigerian Rock Phosphate *v* Superphosphate, Experiment.

Plot.	Crop.	Treatment.	Yield in lb. per Acre of Threshed Grain.		Increase (+) or decrease (−) compared with mean of adjacent controls.
			Controls.	Treatments.	
A 92	Guinea-corn ...	N. R. P. ...	978		
92A	27·5 lb. ...	Superphosphate ...		930	− 9
93	25 „ ...	N. R. P. ...	900		
93A	27·5 „ ...	Superphosphate ...		1,002	+ 18
94	25 „ ...	N. R. P. ...	942		
94A	27·5 „ ...	Superphosphate ...		1,002	+ 102
95	25 „ ...	N. R. P. ...	858		
95A	27·5 „ ...	Superphosphate ..		972	+ 87
96	25 „ ...	N. R. P. ...	912		
96A	27·5 „ ...	Superphosphate ...		960	+ 72
97	25 „ ...	N. R. P. ...	864		
97A	27·5 „ ...	Superphosphate ...		852	+ 24
98	25 „ ...	N. R. P. ...	792		
98A	27·5 „ ...	Superphosphate ...		840	+ 39
99	25 „ ...	N. R. P. ...	810		
99A	27·5 „ ...	Superphosphate ...		792	+ 108
100	25 „ ...	N. R. P. ...	558		
100A	27·5 „ ...	Superphosphate ...		612	− 39
101	25 „ ...	N. R. P. ...	744		
101A	25 „ ...	N. R. P. ...	660		
		Average ...	820	884	+ 52

Variety sown Kaura

Date of sowing, 3rd May, 1928. Date of harvesting, 22nd November, 1928.

Each plot $\frac{1}{3}$ acre.

Average increase (+) or decrease (−) of yield of plots treated with Superphosphate compared with those treated with Nigerian Rock Phosphate. = + 52 ± 71.

Root—mean—square—difference between neighbouring control plots = 212.

Cost of cultivation in man-days per acre = 59.

TABLE No. 6.

Manuring Experiment.

Plot.	Crop.	Treatment.	Yield of Threshed Grain per Acre.		Increase (+) or decrease (−) compared with means of adjacent controls.
			Control plots.	Treatment plots.	
1	Guinea-corn	F.Y.M. 375 tons	808		
1A	do.	N.R.P. 25 lb. ..		942	+84
2	do.	F.Y.M.	912		
2A	do.	No Manure ...		678	−225
3	do.	F.Y.M.	894		
3A	do.	N.R.P. 25 lb. S of Amm. 9375 lb.		991	+87
4	do.	F.Y.M.	912		
4A	do.	N.R.P. 25 lb. Muriate of Potash 7·5 lb. ...		936	−24
5	do.	F.Y.M.	1,008		
5A	do.	F.Y.M. N.R.P. ...		846	+114
6	do.	F.Y.M.	456		
6A	do.	N.R.P. 25 lb. ...		684	+24
7	do.	F.Y.M.	864		
7A	do.	No Manure ...		684	−258
8	do.	F.Y.M.	1,020		
8A	do.	N. R. P. 25 lb. S of Amm. ...		900	+45
9	do.	F.Y.M.	690		
9A	do.	N.R.P. 25 lb. Muriate of Potash		702	−189
10	do.	F.Y.M.	1,092		
10A	do.	F.Y.M. N.R.P.		1,188	+105
11	do.	F.Y.M.	1,074		
11A	do.	N.R.P. 25 lb. ...		1,050	+27
12	do.	F.Y.M.	972		
12A	do.	No Manure ..		582	−312
13	do.	F.Y.M.	816		
13A	do.	N.R.P. 25 lb. S of Amm. ...		690	−84
14	do.	F.Y.M.	732		
14A	do.	N.R.P. 25 lb. Muriate of Potash		702	−114
15	do.	F.Y.M.	900		
15A	do	F.Y.M. N.R.P.		912	+45
16	do.	F.Y.M.	834		
16A	do.	N.R.P. 25 lb. ...		672	−117
17	do.	F.Y.M.	744		
17A	do.	F.Y.M.	793		
		Average ...	862·0		+4·5 −265 +16 −109 +88

TABLE No. 6—*continued.*

Variety sown Kaura. Date of sowing, 3rd May, 1928.

Date of harvesting, 26th November, 1928. Each plot $\frac{1}{8}$ acre

Compared with mean yields of adjacent control plots which received ·375 tons Farm-yard Manure.

The average increase (+) or decrease (−) of yields of those plots receiving 25 lb. Nigerian Rock Phosphate was = + 45 ± 117.

The average increase (+) or decrease (−) of yields of those plots receiving No Manure was = − 265 ± 135.

The average increase (+) or decrease (−) of yields of those plots receiving 25 lb. Nigerian Rock Phosphate + 9·375 lb. Sulphate of Ammonia was + 16±135.

The average increase (+) or decrease (−) of yields of those plots receiving 25 lb. Nigerian Rock Phosphate + 7·5 lb. Muriate of Potash was −109 ± 135.

The average increase (+) or decrease (−) of yields of those plots receiving Farm-yard Manure + Nigerian Rock Phosphate was + 88 ± 135.

Root—mean—square—difference between neighbouring control plots = 233.
Cost of cultivation in man-days per acre = 45.

TABLE No. 7.

Cattle Cultivation Cotton Spacing Experiment.

Plot.	Crop.	Treatment.	Yield of Seed Cotton per Acre.		Increase (+) or decrease (−) compared with means of adjacent controls.	
			Controls.	Treatments.		
B35	Allen Cotton	Stands 1½′ apart	174			
36	〃 〃	〃 1½′ 〃	206			
37	〃 〃	〃 2′ 〃		274	+ 29	
38	〃 〃	〃 1½′ 〃	293			
39	〃 〃	〃 1′ 〃		373		+ 133
40	〃 〃	〃 1½′ 〃	388			
41	〃 〃	〃 2′ 〃		358	− 49	
42	〃 〃	〃 1½′ 〃	426			
43	〃 〃	〃 1′ 〃		369		− 21
44	〃 〃	〃 1½′ 〃	353			
45	〃 〃	〃 2′ 〃		297	+ 6	
46	〃 〃	〃 1½′ 〃	230			
47	〃 〃	〃 1′ 〃		302		+ 38
48	〃 〃	〃 1½′ 〃	299			
49	〃 〃	〃 2′ 〃		281		
50	〃 〃	〃 1½′ 〃	263			
51	〃 〃	〃 1′ 〃		265		+ 28
52	〃 〃	〃 1½′ 〃	212			
53	〃 〃	〃 2′ 〃		294	+ 67	
54	〃 〃	〃 1½′ 〃	243			
55	〃 〃	〃 1′ 〃		286		− 2
56	〃 〃	〃 1½′ 〃	332			
57	〃 〃	〃 2′ 〃		238	− 59	
58	〃 〃	〃 1½′ 〃	261			
59	〃 〃	〃 1′ 〃		225		− 14
60	〃 〃	〃 1½′ 〃	217			
61	〃 〃	〃 2′ 〃		214	+ 9	
62	〃 〃	〃 1½′ 〃	194			
63	〃 〃	〃 1′ 〃		185		− 18
64	〃 〃	〃 1½′ 〃	211			
65	〃 〃	〃 2′ 〃		282	− 52	
66	〃 〃	〃 1½′ 〃	456			
	Average		279		− 6·0	+ 21

Date of sowing, 5th July, 1928. Date of harvesting, 29th December, 1928, 26th January, 1929, 11th and 21st February, 1929.

Each plot ¼ per acre. Dressed with 1 ton. 14 cwt. 2 qr. 19 lb. Farm-yard Manure per acre.

Average increase (+) or decrease (−) of yields of plots planted at 2′ spacing as compared with those with 1½′ spacing = − 6·0 ± 32

Average increase (+) or decrease (−) of yields of plots planted at 1′ spacing as compared with those with 1½′ spacing = + 21 ± 34.

Root—mean—square—difference between neighbouring control plots=91

Cost of cultivation per acre :— Man-days=49·6
Cattle-days= 7·4

TABLE No. 8.

Cattle Cultivation Guinea-corn Spacing Experiment.

Plot.	Crop.	Treatment.	Yield of Threshed Grain per Acre.		Increase (+) or decrease (−) from means of adjacent controls.	
			Controls.	Treatment.		
B69	Guinea-corn.	Stands 5′ apart	797			
70	,,	,, 5′ ,,	819			
71	,,	,, 4′ ,,		813	+ 17	
72	,,	,, 5′ ,,	771			
73	,,	,, 6′ ,,		813		+ 6
74	,,	,, 5′ ,,	842			
75	,,	,, 4′ ,,		832	− 2	
76	,,	,, 5′ ,,	826			
77	,,	,, 6′ ,,		992		+ 197
78	,,	,, 5′ ,,	765			
79	,,	,, 4′ ,,		822	+ 94	
80	,,	,, 5′ ,,	691			
81	,,	,, 6′ ,,		630		+ 18
82	,,	,, 5′ ,,	533			
83	,,	,, 4′ ,,		675	+ 62	
84	,,	,, 5′ ,,	694			
85	,,	,, 6′ ,,		576		− 83
86	,,	,, 5′ ,,	624			
87	,,	,, 4′ ,,		582	− 10	
88	,,	,, 5′ ,,	560			
89	,,	,, 6′ ,,		559		− 26
90	,,	,, 5′ ,,	605			
91	,,	,, 4′ ,,		733	+ 171	
92	,,	,, 5′ ,,	518			
93	,,	,, 6′ ,,		570		− 16
94	,,	,, 5′ ,,	653			
95	,,	,, 4′ ,,		694	+ 90	
96	,,	,, 5′ ,,	557			
97	,,	,, 6′ ,,		512		− 130
98	,,	,, 5′ ,,	728			
99	,,	,, 4′ ,,		845	+ 71·0	
100	,,	,, 5′ ,,	819			
	Average		694	... ...	+ 62	− 5

Variety sown Fara Fara. Date of sowing, 21st May, 1928.

Date of harvesting, 21st November, 1928. Each plot ¼ acre.

Dressed with two tons of Farm-yard Manure per acre.

Average increase (+) or decrease (−) of yields on plots planted with stands 4′ apart as compared with those planted 5′ apart = + 62 ± 35.

Average increase (+) or decrease (−) of yields on plots planted with stands 6′ apart as compared with those planted 5′ apart = − 5 ± 38.

Root—mean—square—difference between neighbouring control plots = 100.

Cost of cultivation :—In man-days per acre = 30·4.

,, cattle-days ,, ,, = 4·4.

TABLE No. 9.

Fodder Crop Experiment.

Plot.	Treatment.	Yield of gero per acre on head.	Yield of guinea-corn per acre on head.	Tolal yield on head.	Increase (+) or decrease (−) from mean of adja cent controls.
C1		480	896	1,376	
2	Removed entirely and F.Y. M. equivalent returned	632	812	1,444	+ 36
3		436	964	1,400	
4	Removed	440	856	1,296	+66
5		460	600	1,060	
6	Turned in for Green Manure	456	780	1,236	+298
7		300	516	816	
8	Folded on plots in November	388	740	1,128	+156
9		420	708	1,128	
10	Removed entirely and F.Y. M. equivalent returned	436	836	1,272	+92
11		412	820	1,232	
12	Removed	300	760	1,060	+2
13		260	624	884	
14	Turned in for Green Manure	264	828	1,092	+234
15		264	568	832	
16	Folded on plots in November	492	748	1,240	+280
17		488	600	1,088	
18	Removed entirely and F.Y. M. equivalent returned	508	772	1,280	+232
19		444	564	1,008	
20	Removed	588	728	1,316	+156
21		568	744	1,312	
22	Turned in for Green Manure	536	624	1,160	−32
23		720	352	1,072	
24	Folded on plots in November	752	792	1,544	+500
25		580	436	1,016	
26	Removed entirely and F.Y. M. equivalent returned	448	284	732	−32
27		240	272	512	
28	Removed	388	404	792	+256
29		332	288	560	
30	Turned in for Green Manure	344	600	944	+314
31		404	292	700	
32	Folded on plots in November	308	252	560	
33		280	244	524	+52
	Average	436	613	1,049	+82 +120 +203 +221

Variety sown Guinea-corn. Kaura. Gero. Mixed.

Date sown Guinea-corn, 12th May, 1928. Date harvested Guinea-corn, 26th November, 1928.

„ „ Gero 26th April, 1928. „ „ Gero 8th August, 1928.

Each plot ¼ acre.

Average increase (+) or decrease (−) of corn on plots after removal of mucuna and return of its F.Y.M. equivalent compared with after guinea-corn = + 82 ± 383.

TABLE No 9—*continued.*

Average increase (+) or decrease (−) of corn on plots after removal of mucuna + no return compared with after guinea-corn = + 120 ± 383.

Average increase (+) or decrease (−) of corn on plots after turning in mucuna for green manure compared with after guinea-corn = + 203 ± 383.

Average increase (+) or decrease (−) of corn on plots after folding mucuna on plots compared with guinea-corn = + 221 ± 383.

Root—mean—square—difference between neighbouring control plots = 766.

Costs of cultivation in man-days per acre :—Gero ... ... = 29.

Guinea-corn ... ... = 43.

TABLE No. 10.

Fodder Crop Experiment.

Recovery of Corn on Treatment Plots.

Plot.	1926. Gero. Increase (+) or decrease (−) compared with mean of gero yield of adjacent controls.	1926. Mean of adjacent guinea-corn plot, *i.e.*, estimated loss of guinea-corn forfeited by growing mucuna.	1926. Nett weight of corn forfeited by growing mucuna.	1927. Guinea-corn recovered. Increase (+) or decrease (−) compared with mean of adjacent controls.	1928. Corn recovered. Guinea-corn and Gero. Increase (+) or decrease (−) compared with mean of adjacent controls.	Balance still to be recovered after third year and end of experiment.
C 2	+ 306	1,128	822	+ 573	+ 36	213 B
4	+ 78	1,059	981	+ 126	+ 66	789 C
6	+ 406	1,001	595	+ 457	+ 298	−160 D
8	+ 228	927	699	− 106	+ 156	649 E
10	+ 154	969	815	+ 195	+ 92	528 B
12	+ 10	889	879	− 50	+ 2	927 C
14	− 74	834	908	+ 310	+ 234	364 D
16	− 130	870	1,000	+ 183	+ 280	537 E
18	− 310	931	1,241	+ 393	+ 232	616 B
20	+ 52	1,027	975	+ 378	+ 156	441 C
22	+ 408	1,069	661	+ 636	− 32	57 D
24	+ 530	849	319	+ 415	+ 500	−596 E
26	− 116	633	749	+ 297	− 32	484 B
28	+ 22	525	503	+ 346	+ 256	− 99 C
30	+ 166	566	400	+ 680	+ 314	−594 D
32	+ 154	632	478	+ 102	− 52	428 E

Balance of corn to be recovered after Mucuna B.	Balance of corn to be recovered after Mucuna C.	Balance of corn to be recovered after Mucuna D.	Balance of corn to be recovered after Mucuna E.
213	789	− 160	649
528	927	364	537
616	441	57	− 596
484	− 99	− 594	428
Average = 460 lb. per acre.	Average = 514 lb. per acre.	Average recovered over and above = 83 lb. per acre.	Average = 254 lb. per acre.

TABLE No. 11.

Cattle Cultivation. Groundnut Spacing Experiment.

Plot.	Crop.	Treatment.	Yield per Acre of unshelled Groundnuts.		Increase (+) or decrease (−) compared with mean of adjacent control plots.	
			Controls.	Treatment.		
C 35	Zaria Groundnuts ...	Stands 2′ apart	648			
36	" " ...	" 2′ "	618			
37	" " ...	" 1½′ "		717	+ 72	
38	" " ...	" 2′ "	672			
39	" " ...	" 1′ "		690		+ 47
40	" " ...	" 2′ "	23			
41	" " ...	" 1½′ "		608	− 46	
42	" " ...	" 2′ "	692			
43	" " ...	" 1′ "		666		+ 54
44	" " ...	" 2′ "	533			
45	" " ...	" 1½′ "		476	− 25	
46	" " ...	" 2′ "	468			
47	" " ...	" 1′ "		521		+ 63
48	" " ...	" 2′ "	447			
49	" " ...	" 1½′ "		570	+ 131	
50	" " ...	" 2′ "	431			
51	" " ...	" 1′ "		449		+ 51
52	" " ...	" 2′ "	365			
53	" " ...	" 1½′ "		317	− 14	
54	" " ...	" 2′ "	297			
55	" " ...	" 1′ "		428		+ 88
56	" " ...	" 2′ "	383			
57	" " ...	" 1½′ "		404	− 61	
58	" " ...	" 2′ "	303			
59	" " ...	" 1′ "		410		+ 129
60	" " ...	" 2′ "	258			
61	" " ...	" 1½′ "		254	− 26	
62	" " ...	" 2′ "	302			
63	" " ...	" 1′ "		404		+ 113
64	" " ...	" 2′ "	279			
65	" " ...	" 1½′ "		345	+ 86	
66	" " ...	" 2′ "	345			
	Average		450	—	+ 30	+ 80

Variety sown Zaria. Date of sowing, 5th June, 1928.

Date of harvesting, 5th November, 1928. Each plot ¼ acre. Bullock cultivation.

Dressed with 1 ton 14 cwt. 2 qr. 19 lb. F.Y.M. per acre.

Average increase (+) or decrease (−) of yield of plots planted with stands 1½′ apart compared with those planted with stands 2′ apart = + 80 ± 24.

Average increase (+) or decrease (−) of yield of plots planted with stands 1′ apart compared with those planted with stands 2′ apart = + 80 ± 26.

Root—mean—square—difference between neighbouring control plots = 69.

Cost of cultivation. Man-days per acre = 72·7.

Cattle-days per acre = 11·2

TABLE No. 12.

Cattle Cultivation. Gero Spacing Experiment.

Plot.	Crop.	Treatment.	Yield of Threshed Grain per Acre.		Increase (+) or decrease (−) from means of adjacent control plots.	
			Controls.	Treatment.		
69	Gero	9 rows	189			
70	„	9 „	254			
71	„	11 „		178	− 20	
72	„	9 „	142			
73	„	7 „		72		− 75
74	„	9 „	153			
75	„	11 „		207	+ 61	
76	„	9 „	146			
77	„	7 „		106		− 92
78	„	9 „	250			
79	„	11 „		274	− 41	
80	„	9 „	380			
81	„	7 „		437		− 46
82	„	9 „	587			
83	„	11 „		562	− 56	
84	„	9 „	648			
85	„	7 „		558		− 63·0
86	„	9 „	594			
87	„	11 „		437	− 86	
88	„	9 „	452			
89	„	7 „		362		− 71
90	„	9 „	414			
91	„	11 „		473	+ 57	
92	„	9 „	419			
93	„	7 „		365		− 70
94	„	9 „	452			
95	„	11 „		392	− 26	
96	„	9 „	385			
97	„	7 „		333		− 36
98	„	9 „	353			
99	„	11 „		412	+ 40	
100	„	9 „	392			
		Average	364	—	— 9	— 65

Variety sown. Mixed. Date of sowing, 14th May, 1928.

Date of harvesting, 20th August, 1928. Each plot ¼ acre.

Average increase (+) or decrease (−) of yield of plots planted in 11 rows as compared with those planted in 9 rows = − 9 ± 32.

Average increase (+) or decrease (−) of yield of plots planted in 7 rows as compared with those planted in 9 rows = − 65 ± 34.

Root—mean—square—difference between neighbouring control plots = 90.

Cost of cultivation in man-days per acre = 28·8.

Cattle-days per acre = 2·0.

TABLE No. 13.

Cattle Cultivation. Mucuna in Gero.

Plot.	Crop.	Treatment.	Yield in lb. per acre of hay.		Increase (+) or decrease (−) as compared with mean of adjacent control plots.	
			Controls	Treatment.		
C 69	Nigerian Mucuna	Interplanted in 9 rows gero	1,168			
70	"	" 9 " "	1,164			
71	"	" 11 " "		1,024	− 50	
72	"	" 9 " "	984			
73	"	" 7 " "		804		−302
74	"	" 9 " "	1,228			
75	"	" 11 " "		1,464	+302	
76	"	" 9 " "	1,096			
77	"	" 7 " "		1,164		− 56
78	"	" 9 " "	1,552			
79	"	" 11 " "		1,512	+146	
80	"	" 9 " "	1,764			
81	"	" 7 " "		1,888		−210
82	"	" 9 " "	2,432			
83	"	" 11 " "		2,620	+ 26	
84	"	" 9 " "	2,756			
85	"	" 7 " "		2,584		− 88
86	"	" 9 " "	2,588			
87	"	" 11 " "		1,828	−392	
88	"	" 9 " "	1,852			
89	"	" 7 " "		1,720		−168
90	"	" 9 " "	1,924			
91	"	" 11 " "		1,992	+268	
92	"	" 9 " "	1,524			
93	"	" 7 " "		1,540		− 78
94	"	" 9 " "	1,712			
95	"	" 11 " "		1,624	+ 16	
96	"	" 9 " "	1,504			
97	"	" 7 " "		1,348		−150
98	"	" 9 " "	1,492			
99	"	" 11 " "		1,488	+144	
100	"	" 9 " "	1,196			
		Average	1631·0		+21	−150

Variety sown − Nigerian Mucuna. Date of sowing, 11th July, 1928.

Date of harvesting, 9th November, 1928. Each plot ¼ acre.

Average increase (+) or decrease (−) of yields of plots planted in 11 rows of Gero compared with those in 9 rows = + 21 ± 123.

Average increase (+) or decrease (−) of yields of plots planted in 7 rows of Gero compared with those in 9 rows = −150 ± 131.

Root—mean—square—difference between neighbouring control plots = 348.

Cost of cultivation in man-days per acre = 20.7.
Cattle-days " " = 1.0.

TABLE No. 14.

GUINEA-CORN. SIZE OF RIDGES EXPERIMENT.

Plot.	Crop.	Treatment.	Yield of Threshed Grain per Acre.		Increase (+) or decrease (−) from mean of adjacent controls.
			Controls.	Treatment.	
D 33	Guinea-corn.	4′ Ridges	714		
34	,,	2½′ ,,		633	−156
35	,,	4′ ,,	864		
36	,,	2½′ ,,		789	−106
37	,,	4′ ,,	927		
38	,,	2½′ ,,		594	−273
39	,,	4′ ,,	808		
40	,,	2½′ ,,		906	+ 51
41	,,	4′ ,,	903		
42	,,	2½′ ,,		876	− 47
43	,,	4′ ,,	942		
44	,,	2½′ ,,		1,008	− 33
45	,,	4′ ,,	1,140		
46	,,	2½′ ,,		897	−274
47	,,	4′ ,,	1,203		
48	,,	2½′ ,,		1,032	−108
49	,,	4′ ,,	1,077		
		Average	953	842	−118

Variety sown – Kaura. Date of sowing, 15th May, 1928.

Date of harvesting, 26th November, 1928. Each plot ¼ acre.

Average increase (+) or decrease (−) of yield on plots planted with 2½′ ridges as compared with those planted with 4′ ridges = −118 ∓ 50.

Root—mean—square—difference between neighbouring control plots = 118.

Cost of cultivation in man-days per acre = 58·5.

TABLE 15.

Cotton. Size of Ridges Experiment.

Plot.	Crop.	Treatment.	Yield of seed Cotton per Acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.	
			Controls.	Treatment.		
D 50	Allen Cotton	4′ Ridges with plants spaced 1′ 3″	196			
51	,,	2½′ ,, ,, ,, ,, 2′		159	−13	
52	,,	4′ ,, ,, ,, ,, 1′ 3″	147			
53	,,	2½′ ,, ,, ,, ,, 1′ 3″		164		−29
54	,,	4′ ,, ,, ,, ,, 1′ 3″	238			
55	,,	2½′ ,, ,, ,, ,, 2′		220	+30	
56	,,	4′ ,, ,, ,, ,, 1′ 3″	142			
57	,,	2½′ ,, ,, ,, ,, 1′ 3″		222		+ 1
58	,,	4′ ,, ,, ,, ,, 1′ 3″	300			
59	,,	2½′ ,, ,, ,, ,, 2′		263	−14	
60	,,	4′ ,, ,, ,, ,, 1′ 3″	254			
61	,,	2½′ ,, ,, ,, ,, 1′ 3″		178		−42
62	,,	4′ ,, ,, ,, ,, 1′ 3″	187			
63	,,	2½′ ,, ,, ,, ,, 2′		171	−15	
64	,,	4′ ,, ,, ,, ,, 1′ 3″	185			
65	,,	2½′ ,, ,, ,, ,, 1′ 3″		152		−58
66	,,	4′ ,, ,, ,, ,, 1′ 3″	234			
		Average	209		−3	−32

Date of sowing, 2nd July, 1928. Date of harvesting, 27th December, 1928, 25th January, 1929, 21st February, 1929.

Average increase (+) or decrease (−) of yield on 4 plots with 2′ 6″ ridges and plants spaced 2′ compared with those on 4′ ridges and plants spaced 1′ 3″ = − 3 ± 41.

Average increase (+) or decrease (−) of yield on 4 plots with 2′ 6″ ridges and plants spaced 1′ 3″ compared with those on 4′ ridges plant spaced 1′ 3″ = − 32 ± 41.

Root—mean—square—difference between adjacent control plots = 82.

Cost of cultivation in man-days per acre = 93.

TABLE No. 16.

Farm Yard Manure *v.* Kraaling Experiment.

Plot.	Crop.	Treatment:	Yield of seed Cotton per acre. Control.	Yield of seed Cotton per acre. Treatments,	Increase (+) or decrease (−) compared with mean of adjacent controls.
E 34	Allen Cotton	Kraaling 400 Cattle Nights	280		
35	,,	F.Y.M. 100 ,, ,,		316	+ 21
36	,,	Kraaling 400 ,, ,,	310		
37	,,	F.Y.M. 200 ,, ,,		292	− 23
38	,,	Kraaling 400 ,, ,,	320		
39	,,	F.Y.M. 300 ,, ,,		316	+ 3
40	,,	Kraaling 400 ,, ,,	306		
41	,,	F.Y.M. 400 ,, ,,		360	− 9
42	,,	Kraaling 400 ,, ,,	397		
43	,,	F.Y.M. 100 ,, ,,		299	− 103
44	,,	Kraaling 400 ,, ,,	406		
45	,,	F.Y.M. 200 ,, ,,		306	− 73
46	,,	Kraaling 400 ,, ,,	351		
47	,,	F.Y.M. 300 ,, ,,		359	+ 13
48	,,	Kraaling 400 ,, ,,	342		
49	,,	F.Y.M. 400 ,, ,,		396	+ 76
50	,,	Kraaling 400 ,, ,,	298		
51	,,	F.Y.M. 100 ,, ,,		244	− 77
52	,,	Kraaling 400 ,, ,,	343		
53	,,	F.Y.M. 200 ,, ,,		312	− 27
54	,,	Kraaling 400 ,, ,,	334		
55	,,	F.Y.M. 300 ,, ,,		393	+ 73
56	,,	Kraaling 400 ,, ,,	306		
57	,,	F.Y.M. 400 ,, ,,		403	+101
58	,,	Kraaling 400 ,, ,,	299		
59	,,	F.Y.M. 100 ,, ,,		226	− 83
60	,,	Kraaling 400 ,, ,,	318		
61	,,	F.Y.M. 200 ,, ,,		329	+ 6
62	,,	Kraaling 400 ,, ,,	328		
63	,,	F.Y.M. 300 ,, ,,		319	− 2
64	,,	Kraaling 400 ,, ,,	314		
65	,,	F.Y.M. 400 ,, ,,		432	+108
66	,,	Kraaling 400 ,, ,,	334		
		Average	329		− 60 − 29 + 22 + 73

Date of sowing, 1st July, 1928. Date of harvesting, 15th December, 1928, 12th January, 1929, 21st February, 1929.

Each plot ¼ acre.

Average increase (+) or decrease (−) of yield of plots receiving *Farm yard Manure 100 Cattle Nights* compared with those of Kraaled plots = − 60 ± 17.

Average increase (+) or decrease (−) of yields of plots receiving *Farm yard Manure 200 Cattle Nights* compared with those of Kraaled plots = − 29 ± 17.

Average increase (+) or decrease (−) of yields of plots receiving *Farm yard Manure 300 Cattle Nights* compared with those of Kraaled plots = + 22 ± 17.

Average increase (+) or decrease (−) of yields of plots receiving *Farm yard Manure 400 Cattle Nights* compared with those of Kraaled plots = + 73 ± 17.

Root—mean—square—difference between neighbouring controls = 34.

Cost of cultivation in man-days per acre = 84.

TABLE No. 17.

Cotton Strain Test.

Plot.	Strain.	Yield of seed cotton per acre. Controls.	Yield of seed cotton per acre. Treatments.	Increase (+) or decrease (−) compared with mean of adjacent controls.	
Bomo C Plot 1	Zaria Ginnery Commercial	274			
„ „ 2	Botanist's D		308	− 9	
„ „ 3	Zaria Ginnery Commercial	360			
„ „ 4	Botanist's E		312		− 25
„ „ 5	Zaria Ginnery Commercial	314			
„ „ 6	Botanist's D		340	− 57	
„ „ 7	Zaria Ginnery Commercial	480			
„ „ 8	Botanist's E		320		− 91
„ „ 9	Zaria Ginnery Commercial	342			
„ „ 10	Botanist's D		216	− 95	
„ „ 11	Zaria Ginnery Commercial	280			
„ „ 12	Botanist's E		236		− 70
„ „ 13	Zaria Ginnery Commercial	332			
„ „ 14	Botanist's D		286	− 25	
„ „ 15	Zaria Ginnery Commercial	290			
„ „ 16	Botanist's E		200		− 57
„ „ 17	Zaria Ginnery Commercial	224			
„ „ 18	Botanist's D		168	− 35	
„ „ 19	Zaria Ginnery Commercial	182			
„ „ 20	Botanist's E		176		− 25
„ „ 21	Zaria Ginnery Commercial	220			
„ „ 22	Botanist's D		168	− 46	
„ „ 23	Zaria Ginnery Commercial	208			
„ „ 24	Botanist's E		168		− 58
„ „ 25	Zaria Ginnery Commercial	244			
„ „ 26	Botanist's D		220	− 12	
„ „ 27	Zaria Ginnery Commercial	220			
„ „ 28	Botanist's E		202		− 43
„ „ 29	Zaria Ginnery Commercial	270			
„ „ 30	Botanist's D		240	− 28	
„ „ 31	Zaria Ginnery Commercial	266			
„ „ 32	Botanist's E		186		− 46
„ „ 33	Zaria Ginnery Commercial	198			
Average control plots		277		− 38	− 52

Date of sowing, 7th July, 1928. Date of harvesting, 31st December, 1928, 14th February, 1929.

Each plot ¼ acre.

Average difference of 8 plots Strain D = − 38 ± 25.

„ „ „ „ E = − 52 ± 25.

Root—mean—square—difference between neighbouring controls =

Cost of Cultivation in man-days per acre = 47·5

TABLE No. 18

	Stock on Hand 1.4.28	Scales.	Deaths.	Transfers.	Births.	Purchases.	Transfers.	Stock on Hand 1.4.29
Stock Bulls	4	...	2	...	...	...	2	4
Cows	30	4	...	3	...	...	...	23
Heifer Calves... ...	15	1	2	4	5	...	...	13
Bull Calves	14	...	4	6	10	...	...	14
Working Cattle ...	6	8	11	4	...	34	1	18

Completed Lactations during Year.

Name of cow.	Number of cow.	Date of calving.	Period of Lactation in Days.	Total Milk Yield in lb.
Bodiye	6	15.12.27	348	1,444½
Gosabiye	34	8.1.28	192	937
Wajuju	4	15.1.28	194	621
Nufu...	19	30.1.28	389	2,879¾
Dupaliye	11	14.2.28	107	848¾
Bojo	17	17.2.28	331	1,523¾

TABLE No. 19.

Cost of Cultivation of Crops for Season, 1928–29, in Man-days per acre.

Crop.		Preparation.	Sowing and Establishing.	After cultivation.	Picking or Harvesting.	Sundry mostly watching.	Total cost.
Cotton		25·8	7·7	37·0	14·2	2·0	86·7
Groundnuts		20·5	5·4	21·2	34·5	13·9	95·5
Guinea-corn		9·1	4·5	31·9	7·2	0·9	53·6
Gero		14·0	3·3	13·1	4·5	2·0	36·9
Mucuna (cut for Hay) ...		21·6	5·2	7·6	9·4	...	43·8
CATTLE CULTIVATION BLOCKS.							
Gero and Mucuna	Man-days...	...	5·7	16·4	4·1	2·6	28·8
	Cattle-days	...	...	2·0	...	...	2·0
	Man-days...	...	5·4	13·1	2·2	...	20·7
	Cattle-days	...	...	1·0	...	...	1·0
Guinea-corn and Cowpeas	Man-days...	...	4·5	21·9	4·0	...	30·4
	Cattle-days	2·2	...	2·2	...	...	4·4
	Man-days...	...	10·3	4·8	7·2	...	22·3
	Cattle-days	...	...	·6	...	...	·6
Cotton ...	Man-days...	...	5·6	28·9	15·1	...	49·6
	Cattle-days	1·4	...	6·0	...	...	7·4
Groundnuts ...	Man-days...	...	4·6	3·2	56·2	8·7	72·7
	Cattle-days	2·0	...	9·2	...	...	11·2

N.B.—1. All charges arising out of the change of ridge size which are not really fair yearly charges are excluded from the above. This includes lining out and spreading manure.

2. A cattle day, which should more correctly be called an "implement" day, consists of the days work of two cattle and two men.

TABLE No. 20.

Comparison of Cost of Production and Revenue from Main Crops, 1928–29.

Crop.	Cost in Man-days per acre.	Average yield in lb. per acre.	Cost in Man-days per lb.	Assumed Market value per lb. in same condition.	Calculated Return per acre, including transport to market.	Gross money return per Man-day in pence.
					£ s. d.	
Cotton	86·7	279 (seed cotton) ...	·323	2·25	2 9 3	6·82
Groundnuts	95·5	433 (decorticated) ...	·220	1·25	2 0 5	5·08
Gero (in Guinea-corn)...	36·9	196 (Grain)	·188	·40	0 4 10	1·58
Gero (in Mucuna) ...	32·8*	364 „	·090	·40	0 9 1	3·32
Guinea-corn	53·6	852 „	·063	·50	1 8 5	6·36
Cowpeas (in Guinea-corn)	8·4	30 (threshed) ...	·280	·50	0 1 0	1·43

* The labour employed in working cattle is included, but not cost of cattle themselves.

KANO PLANTATION, ANNUAL REPORT, 1928.

The following officers were in charge during the year:—

Mr. J. W. R. Pedder from 1st January to 7th March.
„ E. T. Holmes „ 8th March „ 15th August.
„ J. W. R. Pedder „ 16th August „ 31st December.

The climatic conditions throughout the year were fairly satisfactory, the total rainfall being rather above the average. A serious cessation of the rains during the latter part of May and early June was somewhat detrimental to some of the earlier-sown crops.

General.

The crops were on the whole successful, and with the exception of groundnuts good yields were obtained, the cotton yield being exceptionally high. A considerable amount of damage was caused by insect infestation and groundnuts were affected by "bunching" or "rosette" disease. The experimental work met with a considerable amount of success, and more definite results have been obtained from the manurial and exhaustibility tests.

Mixed Farming.

The system of mixed farming employed during the previous season was considerably extended, practically the whole of the cultivation being carried out by this method. Further progress has been made in the cultivation and use of locally made bullock-drawn implements, and as a result of added experience much more satisfactory ploughs and cultivators have been devised.

The scheme for "native farmers' demonstration farms" as outlined in the 1927 Report has been put into operation, and much valuable information has been obtained as to the practicability of introducing the system of mixed-farming to the native. In this way it will be possible to investigate the difficulties experienced by the native in the adoption of this method of cultivation, and as a

result, beneficial modifications and extensions will be made which should be helpful in formulating a policy for the general introduction of this system of mixed farming. For example it has been found that bullocks can easily be trained for the work, and that with training, one man can operate the implement and control the animals without extra assistance.

During the coming year the scheme will be still further extended by the establishment of a "colony" of native farmers who will, under the supervision of the Superintendent of Agriculture, carry out all cultivation by means of this system.

Rainfall and Weather.

See Table No. 1.

The monthly rainfall and temperature are given for the season under review together with the average for the last eight years. The season's rainfall was slightly above average.

Rate of Manuring Experiment, Guinea-corn.
Residual Effect of Manuring.

See Table No. 2.

	Weight unthreshed (on head) in lb. per acre.	Odds that difference is significant.
Average yield of 29 control plots after 5 tons per acre	977	—
Average difference 7 plots after 3 tons per acre	− 67±71	5 : 1
Averge difference 7 plots after 7 tons per acre	+ 83±71	7 : 1
Average difference 7 plots after 9 tons per acre	+ 18±71	—
Average difference 7 plots after 11 tons per acre	+ 95±71	11 : 1

Kano town manure was applied at the above rates to guinea-corn in the preceding year (1927).

It will be observed that the residual effect of this manure is slight. The higher dressings of seven, nine and eleven tons per acre give small residual increases though not proportional to the increase obtained from the lower dressings of three and five tons. This in conjunction with last year's results seems to indicate that the right way to employ manure is in small annual dressings.

ARTIFICIAL MANURE EXPERIMENT, COTTON FOLLOWING GROUNDNUTS.

See Table No. 3.

	Weight of seed cotton lb. per acre.	Odds that difference is significant
Average yield of 17 control plots with F.Y.M. 3 tons per acre	485	—
Average difference 4 plots with Ground Nigerian Rock Phosphate 200 lb. per acre	− 74·5±26·5	390 : 1
Average difference 3 plots with Ground Nigerian Rock Phosphate 200 lb. per acre plus 75 lb. per acre of sulphate of ammonia	− 82 ±31	213 : 1
Average difference 3 plots with no manure	−126 ±31	33,000 : 1
Average difference 3 plots with Ground Nigerian Rock Phosphate 200 lb. per acre plus muriate of potash 60 lb. per acre	− 74 ±31	121 : 1
Average difference 3 plots with Ground Nigerian Rock Phosphate 200 lb. per acre plus F.Y.M. 3 tons per acre ...	− 7 ±31	—

This experiment is a repetition of one which was carried out last year with groundnuts, the results this year again show that, whilst artificial manures have a slight beneficial effect, they are definitely inferior to farm-yard manure. Phosphate alone or in combination with farm-yard manure gives no constant or substantial increase in yield.

PHOSPHATE EXPERIMENT, RESIDUAL EFFECT, GUINEA-CORN.

See Table No. 4 (a).

	Weight on the head in lb. per acre.	Odds that difference is significant.
Average yield of 13 control plots after no manure	787	—
Average difference 4 plots after Kano town manure	−163 ±151	6 : 1
Average difference 4 plots after Ground Rock Phosphate	+ 92 ±151	3 : 1
Average difference 4 plots after Kano town manure and ground rock phosphate	+212·5±151	12 : 1

The above manures were applied to the groundnut crop in 1926 which was followed by cotton in 1927.

The results are not very significant but tend to show that Kano town manure, which is mostly sweepings from compounds, has little or no residual effect.

Phosphate Experiment, Residual Effect, Guinea-corn following Cotton after Mucuna.

See Table No. 4 (b).

	Weight on the head in lb. per acre.	Odds that difference is significant.
Average yield of 13 control plots after no manure	866	—
Average difference 4 plots after Kano town manure	+213 ±136·5	17 : 1
Average difference 4 plots after Ground Rock Phosphate	+164·5 ± 136·5	8 : 1
Average difference 4 plots after town manure and rock phosphate	+324 +136·5	121 : 1

This experiment is comparable with the phosphate experiment Table No. 4 (a) above. In that case the manures were applied in 1926 to groundnuts and gave little result either on that crop or on the succeeding crops of cotton and guinea-corn. In the present instance the manures, originally applied to mucuna, caused a considerable increase in that crop and have also had appreciable residual effects on the succeeding crops. It appears clear that manure cannot be profitably applied to groundnuts.

Treatment of Manure, Guinea-corn.

See Table No. 5.

	Guinea-corn heads in lb. per acre.	Odds that difference is significant.
Average yield 9 control plots manured with native made manure at the rate of 300 cattle nights per acre	583	—
Average difference 4 plots kraaled at the rate of 300 cattle nights per acre ...	− 82·5±78	6 : 1
Average difference 4 plots with F.Y.M. at the rate of 300 cattle nights per acre	+ 81·5±78	6 : 1

This experiment was seriously affected by an attack of cockchafer larvæ in the early stages of growth which necessitated replanting. This accounts for the very poor yield, and the results cannot be relied upon with any degree of confidence.

Exhaustibility Experiment Year II, Guinea-corn.

See Table No. 6.

	Guinea-corn heads in lb. per acre.	Odds that difference is significant.
Average yield 13 control plots following Mucuna, cut and carried off as fodder	1,103	—
Average difference 4 plots following Guinea-corn	−260·75 ± 160	17 : 1
Average difference 4 plots following Groundnuts	+286 ± 160	34 : 1
Average difference 4 plots following cotton	+170 ± 160	6 : 1

These results confirm those obtained from a similar experiment carried out at Samaru, that while guinea-corn is most exhaustive, there is surprisingly little difference between the exhaustive effect of cotton and that of groundnuts.

Width of Ridges Experiment, Cotton.

See Table No. 7.

	Weight of seed cotton in lb. per acre.	Odds that difference is significant.
Average yield of 9 control plots ridges 3 feet 6 inches apart spacing 1 foot 6 inches in the ridge	452	—
Average difference 4 plots ridges 2 feet 6 inches apart spacing 1 foot 6 inches ...	− 29 ± 45	3 : 1
Average difference 4 plots ridges 2 feet 6 inches apart spacing 2 feet 2 inches ...	− 32 ± 45	3 : 1

With cotton neither the changing of the ridges from three feet six inches to two feet six inches apart nor increasing the number of plants per acre gives a statistically significant difference in yield. The decrease on the two feet six inch ridges gives an indication of loss of yield but it is such that it might conceivably be due to experimental error.

Width of Ridges Experiment, Guinea-corn Equal Number of Plants per acre.

See Table No. 8.

	Weight on the head in lb. per acre.	Odds that difference is significant.
Average yield of 9 control plots with ridges 3 feet 6 inches apart	938·5	—
Average difference 8 plots with ridges 2 feet 6 inches apart	− 97·5 ± 90·5	6 : 1

Again as with cotton (*see* Table No. 7), there is no statistically significant decrease of yield, but there is a strong indication of a loss in the neighbourhood of ten *per cent.* The results of these two experiments are important in that they show the loss sustained by reducing the ridges to the width best adapted for cultivation by implements to be inconsiderable compared with the advantages accruing.

Farm-yard Manure *versus* Kraaling, Cotton.

See Table No. 9.

	Weight of seed cotton in lb. per acre.	Odds that difference is significant.
Average yield of 17 control plots with 400 cattle nights per acre kraaled ...	477·5	—
Average difference 4 plots with 400 cattle nights per acre of farm yard manure...	+ 154 ± 40·5	14,285 : 1
Average difference 4 plots with 300 cattle nights per acre of farm yard manure...	+ 56 ± 40·5	11 : 1
Average difference 4 plots with 200 cattle nights per acre of farm yard manure...	+ 34 ± 40·5	4 : 1
Average difference 4 plots with 100 cattle nights per acre of farm yard manure...	− 38 ± 40·5	5 : 1

This experiment demonstrates that the manure of a given number of cattle can be approximately doubled in effect by its conversion into farm-yard manure.

The results of this experiment confirm a similar one carried out at Samaru in 1926.

Date of Planting Test Mucuna.

See Table No. 10.

	Weight of dry hay in lb. per acre.	Odds that difference is significant.
Average yield of 13 control plots, sown June 15th	9,281·5	—
Average difference 4 plots, sown May 6th	− 464·5 ± 1,213	less than 2 : 1
Average difference 4 plots, sown May 27th	+3,396·5 ± 1,213	390 : 1
Average difference 4 plots, sown July 7th	−3,361 ± 1,213	335 : 1

The first date of planting was determined by the first rains, yields were calculated as "one day dried hay."

The significant results show the optimum date of planting is when the rains are firmly established; in this case three weeks after the first rain.

Interplanting Gero in Mucuna Experiment, Yields of Mucuna.

See Table No. 11.

	Weight of dry mucuna hay in lb. per acre.	Odds that difference is significant.
Average yield of 15 control plots with 5 rows gero, 6 feet apart	1,674	-
Average difference 4 plots with no gero...	+3,004 ± 421 over	100,000 : 1
Average difference 5 plots with 3 rows gero, 11 feet apart	— 11 ± 376	—
Average difference 5 plots with 7 rows gero, 4 feet apart	— 6 ± 376	—

Interplanting Gero in Mucuna Experiment, Yields of Gero

See Table No. 12.

	Weight of gero (pennisetum typhoideum) on the head in lb. per acre.	Odds that difference is significant.
Average yield of 15 control plots with 5 rows, 6 feet apart	1,268·5	—
Average difference 5 plots with 3 rows gero, 11 feet apart	— 65 ± 100·5	3 : 1
Average difference 5 plots with 7 rows gero, 4 feet apart	— 4·5 ± 100·5	—

There is no difference in the yield of mucuna whether three, five, or seven rows of gero are planted, but where no gero is planted there is a large increase. The yields of gero also are apparently not affected by the number of rows per plot. Thus it would appear that for the loss of 3,000 lb. of mucuna hay one gains approximately 1,200 lb. of gero. These somewhat remarkable results cannot be accepted without corroboration.

Cost of Main Crops in Man-day per acre.

See Table No. 13.

Due to heavier yields of legumes, cotton and gero the costs in man-days per acre are greater than in previous years. These costs, however, are considerably lower than those on other plantations where bullock-drawn implements are not so extensively used.

TABLE No. 1.

Monthly Rainfall and Mean Temperature.

Month.	Rainfall in inches, Plantation.	Rainfall in inches, Survey School.	Average fall over 8 years, Survey School.	Mean Temperature.	Mean Temperature over 8 years.
January ...	...	·06	·01	76·5	70·4
February ...	...	...	...	75·3	75·4
March ...	...	·05	·11	87·3	83·3
April ...	·54	·46	·37	89·2	88·9
May	4·57	4·74	1·91	86·8	88·3
June	4·78	3·67	3·99	82·6	83·9
July	6·98	7·79	7·18	80·0	79·9
August ..	10·57	11·28	12·17	78·7	78·2
September ...	6·17	5·22	5·54	80·9	80·3
October ...	1·50	1·67	0·80	82·0	81·0
November ...	...	...	...	77·5	79·2
December ...	...	..	...	72·1	72·6
Total ...	35·18	34·94	32·08	80·7	80·1

TABLE No. 2.

Rate of Manuring Experiment Guinea-corn.

Residual Effect of Manuring.

No. of Plot.	Treatment.	Weight on the head in lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
K. 1–59				
1	At rate of 5 tons per acre (standard)	1,436		
2	" " " 3 " " "		1,098	− 158
3	" " " 5 " " "	1,077		
4	" " " 11 " " "		1,341	+ 330
5	" " " 5 " " "	945		
6	" " " 7 " " "		802	− 208
7	" " " 5 " " "	1,075		
8	" " " 9 " " "		1,206	+ 106
9	" " " 5 " " "	1,124		
10	" " " 3 " " "		873	− 317
11	" " " 5 " " "	1,257		
12	" " " 11 " " "		1,387	+ 97
13	" " " 5 " " "	1,324		
14	" " " 7 " " "		1,545	+ 320
15	" " " 5 " " "	1,127		
16	" " " 9 " " "		1,033	+ 72
17	" " " 5 " " "	775		
18	" " " 3 " " "		698	− 74
19	" " " 5 " " "	770		
20	" " " 11 " " "		850	+ 165
21	" " " 5 " " "	600		
22	" " " 7 " " "		520	− 123
23	" " " 5 " " "	687		
24	" " " 9 " " "		590	− 20
25	" " " 5 " " "	534		
26	" " " 3 " " "		507	+ 5
27	" " " 5 " " "	470		
28	" " " 11 " " "		632	+ 17
29	" " " 5 " " "	760		
30	" " " 7 " " "		771	+ 54
31	" " " 5 " " "	675		
32	" " " 9 " " "		596	− 94
33	" " " 5 " " "	705		
34	" " " 3 " " "		739	− 38
35	" " " 5 " " "	850		
36	" " " 11 " " "		903	+ 1
37	" " " 5 " " "	955		
38	" " " 7 " " "		1,142	+ 132
39	" " " 5 " " "	1,065		
40	" " " 9 " " "		840	− 130
41	" " " 5 " " "	876		
42	" " " 5 " " "	890		Non-experimental.
43	" " " 5 " " "	1,238		

TABLE No. 2—*continued.*

No. of Plot.	Treatment.	Weight on the head in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
44	At rate of 3 tons per acre (standard)	1,023	− 137
45	„ „ „ 5 „ „ „	1,082	
46	„ „ „ 11 „ „ „	1,013	− 50
47	„ „ „ 5 „ „ „	1,044	
48	„ „ „ 7 „ „ „	1,324	+ 117
49	„ „ „ 5 „ „ „	1,371	
50	„ „ „ 9 „ „ „	1,278	+ 30
51	„ „ „ 5 „ „ „	1,126	
52	„ „ „ 3 „ „ „	1,513	+ 251
53	„ „ „ 5 „ „ „	1,399	
54	„ „ „ 11 „ „ „	1,318	+ 105
55	„ „ „ 5 „ „ „	1,027	
56	„ „ „ 7 „ „ „	1,271	+ 288
57	„ „ „ 5 „ „ „	940	
58	„ „ „ 9 „ „ „	1,131	+ 163
59	„ „ „ 5 „ „ „	997	

Each Plot ¼ acre. Sown 21st May, 1928. Harvested 13th–23rd November, 1928. 2′ 6″ ridges. Bullock and hand cultivation.

Increase (+) or decrease (−) of 7 plots with 3 tons per acre compared with 5 tons per acre.

− 158
− 317
− 74
+ 5
− 38
− 137
+ 251

Average − 69 ± 71 lb. per acre.

Increase (+) or decrease (−) of 7 plots with 7 tons per acre compared with 5 tons per acre.

− 208
+ 320
− 123
+ 54
+ 132
+ 117
+ 288

Average + 83 ± 71 lb. per acre.

Increase (+) or decrease (−) of 7 plots with 9 tons per acre compared with 5 tons per acre.

+ 106
+ 72
− 20
− 94
− 130
+ 30
+ 163

Average + 18 ± 71 lb. per acre.

Increase (+) or decrease (−) of 7 plots with 11 tons per acre compared with 5 tons per acre.

+ 330
+ 97
+ 165
+ 17
+ 1
− 50
+ 105

Average + 95 ± 71 lb. per acre.

Root-mean-square difference between pairs of neighbouring controls = 189·3.

Cost of cultivation in man-days per acre = 48·4.

TABLE No. 3.

Artificial Manure Experiment, Cotton.

No. of Plot.		Treatment.	Weight of seed cotton in lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
I. 43–59.					
43	1	Farm-yard manure 3 tons per acre (standard)	434		
	2	200 lb. per acre of rock phosphate		300	− 131
44	1	Farm-yard manure 3 tons per acre	428		
	2	Unmanured		366	− 125
45	1	Farm-yard manure 3 tons per acre	554		
	2	200 lb. of rock phosphate plus 75 lb. sulphate of ammonia		488	− 69
46	1	Farm-yard manure 3 tons per acre	560		
	2	200 lb. of rock phosphate plus 60 lb. of muriate of potash		524	− 46
47	1	Farm-yard manure 3 tons per acre	580		
	2	Farm-yard manure 3 tons per acre plus 200 lb. rock phosphate per acre		532	− 24
48	1	Farm-yard manure 3 tons per acre	532		
	2	200 lb. per acre rock phosphate		448	− 59
49	1	Farm-yard manure 3 tons per acre	482		
	2	Unmanured		312	− 177
50	1	Farm-yard manure 3 tons per acre	496		
	2	200 lb. of rock phosphate plus 75 lb. of sulphate of ammonia		400	− 138
51	1	Farm-yard manure 3 tons per acre	580		
	2	200 lb. of rock phosphate plus 60 lb. of muriate of potash		472	− 105
52	1	Farm-yard manure 3 tons per acre	574		
	2	Farm-yard manure 3 tons per acre plus 200 lb. rock phosphate per acre		536	− 26
53	1	Farm-yard manure 3 tons per acre	550		
	2	200 lb. per acre rock phosphate		454	− 59
54	1	Farm-yard manure 3 tons per acre	476		
	2	Unmanured		416	− 75
55	1	Farm-yard manure 3 tons per acre	506		
	2	200 lb. of rock phosphate plus 75 lb. of sulphate of ammonia		428	− 38
56	1	Farm-yard manure 3 tons per acre	426		
	2	200 lb. of rock phosphate plus 60 lb. of muriate of potash ...		330	− 72
57	1	Farm-yard manure 3 tons per acre	378		
	2	Farm-yard manure 3 tons per acre plus 200 lb. rock phosphate per acre		390	+ 30

TABLE No 3.—*continued.*

No. of Plot.		Treatment.	Weight of seed cotton in lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
58	1	Farm-yard manure 3 tons per acre	342		
	2	200 lb. per acre of rock phosphate...		298	− 49
59	1	Farm-yard manure 3 tons per acre	352		
	2	Farm-yard manure 3 tons per acre	428		Non-experimental.

Each plot ⅛ acre. Sown 21st June, 1928. Harvested 3rd, 28th November, 1928; 10th December, 1928; 18th December, 1928; 21st January, 1929. 2′ 6″ ridges. Bullock cultivation.

Increase (+) or decrease (−) of 4 plots with P_2O_5 200 lb. per acre compared with those with Pen Made Manure 3 tons per acre.

− 131
− 59
− 59
− 49

Average − 74·5 ± 26·5 lb. per acre.

Increase (+) or decrease (−) of 3 plots with no manure compared with those with Pen Made manure 3 tons per acre.

− 125
− 177
− 75

Average − 126 ± 31 lb. per acre.

Increase (+) or decrease (−) of 3 plots with P_2O_5 200 lb. per acre + $(NH_4)_2SO_4$ 75 lb. per acre compared with those with Pen Made manure 3 tons per acre.

− 69
− 138
− 38

Average − 82 ± 31 lb. per acre.

Increase (+) or decrease (−) of 3 plots with P_2O_5 200 lb. per acre + K_2O 60 lb. per acre compared with those with Pen Made manure 3 tons per acre.

− 46
− 105
− 72

Average − 74 ± 31 lb. per acre.

Increase (+) or decrease (−) of 3 plots with P_2O_5 200 lb. per acre + Pen Made manure 3 tons per acre compared with those with Pen Made manure 3 tons per acre.

− 24
− 26
+ 30

Average − 7 ± 31 lb. per acre.

Root—mean—square—difference between pairs of neighbouring control plots 53·3.

Cost of cultivation in man-days per acre = 71.

TABLE No. 4 (*a*).

PHOSPHATE EXPERIMENT—RESIDUAL EFFECT GUINEA-CORN.

No. of Plot.	Treatment.	Weight on the head in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
E. 1–25.			
1	Unmanured	1,570	
2	Town manure	540	− 677
3	Unmanured	865	
4	Rock phosphate	1,175	+ 498
5	Unmanured	490	
6	Town manure and rock phosphate	920	+ 265
7	Unmanured	820	
8	Town manure	850	+ 28
9	Unmanured	825	
10	Rock phosphate	715	− 137
11	Unmanured	880	
12	Town manure and rock phosphate	1,290	+ 460
13	Unmanured	780	
14	Town manure	895	+ 53
15	Unmanured	905	
16	Rock phosphate	645	− 20
17	Unmanured	425	
18	Town manure and rock phosphate	635	+ 175
19	Unmanured	495	
20	Town manure	475	− 55
21	Unmanured	565	
22	Rock phosphate	610	+ 28
23	Unmanured	600	
24	Town manure and rock phosphate	690	− 50
25	Unmanured	880	

Each plot $\frac{1}{20}$ acre. Sown 15th May, 1928. Harvested 21st November, 1928.
2′ 6″ ridges. Bullock cultivation.

Increase (+) or decrease (−) of 4 plots with N_2 added compared with unmanured.	Increase (+) or decrease (−) of 4 plots with P_2O_5 added compared with unmanured.	Increase (+) or decrease (−) of 4 plots with N_2 + P_2O_5 added compared with unmanured.
−677	+498	+265
+ 28	−137	+460
+ 53	− 20	+175
− 55	+ 28	− 50
Average −163 ± 151 lb. per acre.	Average −92 ± 151 lb. per acre.	Average +212·5 ± 151 lb. per acre.

Root—mean—square—difference between pairs of neighbouring controls = 302·5.

Cost of cultivation in man-days per acre = 37·4.

TABLE No. 4 (*b*).

PHOSPHATE EXPERIMENT—RESIDUAL EFFECT GUINEA-CORN.

No. of Plot.	Treatment.	Weight on the head in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
E. 1–25			
1	Unmanured	555	
2	Town manure	1,020	+ 298
3	Unmanured	890	
4	Rock phosphate ...	1,450	+ 473
5	Unmanured	1,065	
6	Town manure and rock phosphate	1,220	+ 335
7	Unmanured	705	
8	Town manure	950	+ 55
9	Unmanured	1,085	
10	Rock phosphate ...	1,000	± 0
11	Unmanured	915	
12	Town manure and rock phosphate	1,525	+ 685
13	Unmanured	765	
14	Town manure	1,400	+ 465
15	Unmanured	1,105	
16	Rock phosphate ...	975	+ 120
17	Unmanured	605	
18	Town manure and rock phosphate	745	+ 65
19	Unmanured	755	
20	Town manure	820	+ 35
21	Unmanured	815	
22	Rock phosphate ...	970	+ 65
23	Unmanured	995	
24	Town manure and rock phosphate	1,210	+ 210
25	Unmanured	1,005	

Each plot $\frac{1}{20}$ acre. Sown 15th May, 1928. Harvested 21st November, 1928.
2′ 6″ ridges. Bullock cultivation.

Increase (+) or decrease (−) of 4 plots with N_2 compared with unmanured.	Increase (+) or decrease (−) of 4 plots with P_2O_5 compared with unmanured.	Increase (+) or decrease (−) of 4 plots with N_2 + P_2O_5 compared with unmanured.
+ 298	+ 473	+ 335
+ 55	+ 0	+ 685
+ 465	+ 120	− 65
+ 35	+ 65	+ 210
Average + 213 ± 136·5 lb. per acre.	Average + 164·5 ± 136·5 lb. per acre.	Average + 324 ± 136·5 lb. per acre.

Root—mean—square—difference between pairs of neighbouring controls = 273.

Cost of cultivation in man-days per acre = 37·4.

TABLE No. 5.

Treatment of Manure Experiment, Guineacorn.

Native Method versus *Kraaled and F.Y.M. 300 Cattle Nights per acre.*

No. of Plot.	Treatment.	Weight on the head in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
B. 1–17			
1	Native method	641	
2	Kraaled	648	− 19
3	Native method	693	
4	F. Y. M.	716	+ 43
5	Native method	653	
6	Kraaled	346	− 210
7	Native method	460	
8	F. Y. M.	359	− 58
9	Native method	375	
10	Kraaled	456	− 71
11	Native method	679	
12	F. Y. M.	768	+ 114
13	Native method	630	
14	Kraaled	522	− 30
15	Native method	474	
16	F. Y. M.	784	+ 227
17	Native method	641	

Each plot ¼ acre. Sown 15th May, 1928. Harvested 20th November, 1928.

2′ 6″ ridges. Bullock and hand cultivation.

Increase (+) or decrease (−) of 4 plots kraaled compared with native method.	Increase (+) or decrease (−) of 4 plots F. Y. M. compared with native method.
− 19	+ 43
− 210	− 58
− 71	+ 114
− 30	+ 227
Average − 82·5 ± 78 lb. per acre	Average + 81·5 ± 78 lb. per acre.

Root—mean square—difference between pairs of neighbouring controls = **156.**

Cost of cultivation in man-days per acre = 51·2.

TABLE No. 6.

EXHAUSTIBILITY EXPERIMENT YEAR II, GUINEA-CORN.

No. of Plot.	Previous Crops.	Weight on the head in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
A. 26–50			
26	Guinea-corn after Mucuna ...	530	
27	,, ,, Guinea-corn ...	730	+ 37
28	,, ,, Mucuna ...	856	
29	,, ,, Groundnuts ...	1,320	+ 255
30	,, ,, Mucuna ...	1,274	
31	,, ,, Cotton ...	1,150	+ 27
32	,, ,, Mucuna ...	971	
33	,, ,, Guinea-corn ...	887	− 321
34	,, ,, Mucuna ...	1,444	
35	,, ,, Groundnuts ...	1,508	+ 119
36	,, ,, Mucuna ...	1,334	
37	,, ,, Cotton ...	1,381	+ 110
38	,, ,, Mucuna ...	1,208	
39	,, ,, Guinea-corn ...	726	− 332
40	,, ,, Mucuna ...	908	
41	,, ,, Groundnuts ...	1,378	+ 529
42	,, ,, Mucuna ...	790	
43	,, ,, Cotton ..	1,293	+ 170
44	,, ,, Mucuna ...	1,456	
45	,, ,, Guinea-corn ...	1,128	− 227
46	,, ,, Mucuna ...	1,254	
47	,, ,, Groundnuts ...	1,472	+ 241
48	,, ,, Mucuna ...	1,209	
49	,, ,, Cotton ...	1,529	+ 373
50	,, ,, Mucuna ...	1,102	

Each plot ¼ acre. Sown 7th May, 1928. Harvested 20th November, 1928.

2′ 6″ ridges. Bullock and hand cultivation.

Increase (+) or decrease (−) of 4 plots of guinea-corn following guinea-corn compared with that following mucuna.	Increase (+) or decrease (−) of 4 plots of guinea-corn following groundnuts compared with that following mucuna.	Increase (+) or decrease (−) of 4 plots of guinea-corn following cotton compared with that following mucuna.
+ 37	+ 255	+ 27
− 321	+ 119	+ 110
− 332	+ 529	+ 170
− 227	+ 241	+ 373
Average −260·75 ± 160 lb. per acre.	Average +286 ± 160 lb. per acre.	Average +170 ± 160 lb per acre.

Root—mean—square—difference between pairs of neighbouring controls = 320.

Cost of cultivation in man-days per acre = 43·4.

TABLE No. 7.

Width of Ridges Experiment, Cotton.

No. of Plot.	Width of Ridges.	Weight of seed cotton in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
H. 43–59			
43	Ridges 3′ 6″ apart, Spacing 1′ 6″	598	
44	„ 2′ 6″ „ „ 1′ 6″	423	− 149
45	„ 3′ 6″ „ „ 1′ 6″	547	
46	„ 2′ 6″ „ „ 2′ 2″	423	− 29
47	„ 3′ 6″ „ „ 1′ 6″	356	
48	„ 2′ 6″ „ „ 1′ 6″	421	+ 10
49	„ 3′ 6″ „ „ 1′ 6″	466	
50	„ 2′ 6″ „ „ 2′ 2″	405	− 38
51	„ 3′ 6″ „ „ 1′ 6″	420	
52	„ 2′ 6″ „ „ 1′ 6″	438	− 7
53	„ 3′ 6″ „ „ 1′ 6″	470	
54	„ 2′ 6″ „ „ 2′ 2″	401	− 66
55	„ 3′ 6″ „ „ 1′ 6″	464	
56	„ 2′ 6″ „ „ 1′ 6″	445	+ 28
57	„ 3′ 6″ „ „ 1′ 6″	369	
58	„ 2′ 6″ „ „ 2′ 2″	377	+ 4
59	„ 3′ 6″ „ „ 1′ 6″	376	

Each plot ¼ acre. Harvested 3rd and 20th November, 1928; 6th and 15th December, 1928; 18th January, 1929.

Hand cultivation.

Increase (+) or decrease (−) of 4 plots with ridges 2′ 6″ apart and plants spaced 1′ 6″ compared with those 3′ 6″ apart and spaced 1′ 6″.

− 149
+ 10
− 7
+ 28

Average − 29 ± 45 lb per acre.

Increase (+) or decrease (−) of 4 plots with ridges 2′ 6″ apart and plants spaced 2′ 2″ compared with those 3′ 6″ and spaced 1′ 6″.

− 29
− 38
− 66
+ 4

Average ± 32 ∓ 45 lb per acre.

Root—mean—square—difference between pairs of neighbouring controls = 90·0.

Cost of cultivation in man-days per acre = 72.

TABLE No. 8.

Width of Ridges Experiment, Guinea-corn.

Equal number of Plants per acre.

No. of Plot.	Width of Ridges.	Weight on the head in lb per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
B. 18–34			
18	With ridges 3′ 6″ apart ...	597	
19	,, ,, 2′ 6″ ,, ...	347	− 182
20	,, ,, 3′ 6″ ,, ...	462	
21	,, ,, 2′ 6″ ,, ...	607	− 31
22	,, ,, 3′ 6″ ,, ...	814	
23	,, ,, 2′ 6″ ,, ...	630	− 207
24	,, ,, 3′ 6″ ,, ...	860	
25	,, ,, 2′ 6″ ,, ...	913	− 57
26	,, ,, 3′ 6″ ,, ...	1,080	
27	,, ,, 2′ 6″ ,, ...	1,012	− 194
28	,, ,, 3′ 6″ ,, ...	1,332	
29	,, ,, 2′ 6″ ,, ...	1,039	− 130
30	,, ,, 3′ 6″ ,, ...	1,006	
31	,, ,, 2′ 6″ ,, ...	906	− 68
32	,, ,, 3′ 6″ ,, ...	943	
33	,, ,, 2′ 6″ ,, ...	1,237	+ 89
34	,, ,, 3′ 6″ ,, ...	1,353	

Each plot ¼ acre. Sown 6th May, 1928. Harvested 13th to 19th November, 1928.

Hand cultivation.

Increase (+) or decrease (−) of 8 plots with ridges 2′ 6″ apart compared with those 3′ 6″ apart
− 182
− 31
− 207
− 57
− 194
− 130
− 68
+ 89
Average − 97·5±90·5 lb per acre.

Root—mean—square—difference between pairs of neighbouring controls = 258·3.

Cost of cultivation in man-days per acre = 54·8.

TABLE No. 9.

Farm Yard Manure *versus* Kraaling Experiment, Cotton.

No. of Plot.	Treatment.	Weight of seed cotton in lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
I. 1–33.				
1	At rate of 400 cattle nights per acre, Kraaled...	477		
2	„ „ 400 „ „ Pen Made		654	+ 179
3	„ „ 400 „ „ Kraaled...	473		
4	„ „ 300 „ „ Pen Made		573	+ 79
5	„ „ 400 „ „ Kraaled...	516		
6	„ „ 200 „ „ Pen Made		551	+ 83
7	„ „ 400 „ „ Kraaled...	421		
8	„ „ 100 „ „ Pen Made		377	− 81
9	„ „ 400 „ „ Kraaled...	498		
10	„ „ 400 „ „ Pen Made		676	+ 243
11	„ „ 400 „ „ Kraaled...	369		
12	„ „ 300 „ „ Pen Made		407	+ 53
13	„ „ 400 „ „ Kraaled...	339		
14	„ „ 200 „ „ Pen Made		268	− 66
15	„ „ 400 „ „ Kraaled...	330		
16	„ „ 100 „ „ Pen Made		266	− 75
17	„ „ 400 „ „ Kraaled...	353		
18	„ „ 400 „ „ Pen Made		503	+ 134
19	„ „ 400 „ „ Kraaled...	385		
20	„ „ 300 „ „ Pen Made		453	+ 56
21	„ „ 400 „ „ Kraaled...	409		
22	„ „ 200 „ „ Pen Made		525	+ 40
23	„ „ 400 „ „ Kraaled...	562		
24	„ „ 100 „ „ Pen Made		641	+ 9
25	„ „ 400 „ „ Kraaled...	703		
26	„ „ 400 „ „ Pen Made		757	+ 59
27	„ „ 400 „ „ Kraaled...	694		
28	„ „ 300 „ „ Pen Made		654	+ 36
29	„ „ 400 „ „ Kraaled...	542		
30	„ „ 200 „ „ Pen Made		602	+ 78
31	„ „ 400 „ „ Kraaled...	507		
32	„ „ 100 „ „ Pen Made		520	− 4
33	„ „ 400 „ „ Kraaled...	541		

Each plot $\frac{1}{4}$ acre. Sown 17th and 18th June, 1928. Harvested 3rd November, 1928; 3rd and 12th December, 1928; 12th January, 1929. 2′ 6″ ridges. Bullock cultivation.

TABLE No. 9—*continued.*

Increase (+) or decrease (−) of 4 plots with 400 cattle nights per acre Pen Made compared with those with 400 cattle nights per acre Kraaled.

+	179
+	243
+	134
+	59
Average +	154 ± 40·5 lb. per acre.

Increase (+) or decrease (−) of 4 plots with 400 cattle nights per acre Pen Made compared with those with 400 cattle nights per acre Kraaled.

+	79
+	53
+	56
+	36
Average +	56 ± 40·5 lb. per acre.

Increase (+) or decrease (−) of 4 plots with 200 cattle nights per acre Pen Made compared with those with 400 cattle nights per acre Kraaled.

+	83
−	66
+	40
+	78
Average +	34 ± 40·5 lb. per acre.

Increase (+) or decrease (−) of 4 plots with 100 cattle nights per acre Pen Made compared with those with 400 cattle nights per acre Kraaled.

−	81
−	75
+	9
−	4
Average −	38 ± 40·5 lb. per acre.

Root—mean—square—difference between pairs of neighbouring controls = 81·18.

Cost of cultivation in man-days per acre = 66.

TABLE No. 10.

Date of Planting Test—Mucuna.

No. of Plot.	Date of Planting.	Weight of dry hay in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
A. 1–25.			
1	Planted June 15th ...	6,848	
2	„ May 6th ...	6,560	− 1,368
3	„ June 15th ...	9,008	
4	„ May 27th ...	13,616	+ 2,804
5	„ June 15th ...	12,616	
6	„ July 7th ...	8,276	− 4,684
7	„ June 15th ..	13,304	
8	„ May 6th ...	12,488	+ 388
9	„ June 15th ...	10,896	
10	„ May 27th ...	15,316	+ 5,032
11	„ June 15th ...	9,672	
12	„ July 7th ...	5,764	− 2,320
13	„ June 15th ...	6,496	
14	„ May 6th ...	6,996	− 282
15	„ June 15th ...	8,060	
16	„ May 27th ...	10,252	+ 3,840
17	„ June 15th ...	4,764	
18	„ July 7th ...	3,348	− 3,138
19	„ June 15th ...	8,208	
20	„ May 6th ...	8,960	− 590
21	„ June 15th ...	10,904	
22	„ May 27th ...	12,872	+ 1,910
23	„ June 15th ...	11,020	
24	„ July 7th ...	6,928	− 3,302
25	„ June 15th ...	9,440	

Each plot ¼ acre. Harvested 26th October, 1928. 10th November, 1928.
2' 6" ridges. Bullock and hand cultivation.

Increase (+) or decrease (−) of 4 plots sown May 6th compared with that sown June 15th.	Increase (+) or decrease (−) of 4 plots sown May 27th compared with that sown June 15th.	Increase (+) or decrease (−) of 4 plots sown July 7th compared with that sown June 15th.
− 1,368	+ 2,804	− 4,684
+ 388	+ 5,032	− 2,320
− 282	+ 3,840	− 3,138
− 596	+ 1,910	− 3,302
Average − 464·5±1,213 lb. per acre.	Average + 3,396·5±1,213 lb. per acre.	Average − 3,361±1,213 lb. per acre.

Root—mean—square—difference between pairs of neighbouring controls = 2,426·5

Cost of cultivation in man-days per acre = 80·3.

TABLE No. 11.

Interplanting Gero in Mucuna Experiment, Yields of Mucuna.

No. of plot.	Interplanting.	Weight of dry hay in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
M. 1–29.			
1	Mucuna with 5 lines gero interplanted	1,472	
2	Mucuna with no lines gero interplanted	7,964	+ 5,788
3	Mucuna with 5 lines gero interplanted	2,880	
4	Mucuna with 3 lines gero interplanted	2,440	+ 84
5	Mucuna with 5 lines gero interplanted	1,832	
6	Mucuna with 7 lines gero interplanted	2,872	+ 278
7	Mucuna with 5 lines gero interplanted	3,356	
8	Mucuna with no lines gero interplanted	7,600	+ 3,914
9	Mucuna with 5 lines gero interplanted	4,016	
10	Mucuna with 3 lines gero interplanted	3,176	+ 414
11	Mucuna with 5 lines gero interplanted	2,308	
12	Mucuna with 7 lines gero interplanted	1,972	− 580
13	Mucuna with 5 lines gero interplanted	2,796	
14	Mucuna with no lines gero interplanted	2,792	+ 706
15	Mucuna with 5 lines gero interplanted	1,376	
16	Mucuna with 3 lines gero interplanted	984	− 322
17	Mucuna with 5 lines gero interplanted	1,236	
18	Mucuna with 7 lines gero interplanted	1,508	+ 366
19	Mucuna with 5 lines gero interplanted	1,048	
20	Mucuna with no lines gero interplanted	2,472	+ 1,690
21	Mucuna with 5 lines gero interplanted	516	
22	Mucuna with 3 lines gero interplanted	224	− 110
23	Mucuna with 5 lines gero interplanted	152	
24	Mucuna with 7 lines gero interplanted	128	− 44
25	Mucuna with 5 lines gero interplanted	192	
26	Mucuna with 3 lines gero interplanted	244	− 122
27	Mucuna with 5 lines gero interplanted	540	
28	Mucuna with 7 lines gero interplanted	916	− 50
29	Mucuna with 5 lines gero interplanted	1,392	

Each plot ¼ acre. Sown 27th to 29th May, 1928. Harvested 6th to 12th November, 1928.

2′ 6″ ridges. Bullock and hand cultivation.

TABLE No. 11—*continued.*

Increase (+) or decrease (−) of 4 plots with no gero compared with 5 rows gero.	Increase (+) or decrease (−) of 5 plots with 3 rows gero compared with 5 rows gero.	Increase (+) or decrease (−) of 5 plots with 7 rows gero compared with 5 rows gero.
+ 5,788	+ 84	+ 278
+ 3,914	+ 414	− 580
+ 706	− 322	+ 366
+ 1,609	− 110	− 44
	− 122	− 50
Average + 3,004±421 lb. per acre.	Average − 11±376 lb. per acre.	Average − 6±376 lb. per acre.

Root—mean—square—difference between pair of neighbouring controls = 842.

Cost of cultivation in man-days per acre, 54·0.

TABLE No. 12.

Interplanting Gero in Mucuna Experiment, Yields of Gero.

No. of Plot.	Interplanting.	Weight on the head in lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
M. 1–29.				
1	Mucuna with 5 lines gero interplanted ...	1,368		
2	„ „ no „ „ „ ...			
3	„ „ 5 „ „ „ ...	1,320		
4	„ „ 3 „ „ „ ...		940	− 230
5	„ „ 5 „ „ „ ...	1,020		
6	„ „ 7 „ „ „ ...		904	− 138
7	„ „ 5 „ „ „ ...	1,064		
8	„ „ no „ „ „ ...			
9	„ „ 5 „ „ „ ...	1,196		
10	„ „ 3 „ „ „ ...		1,224	− 18
11	„ „ 5 „ „ „ ...	1,288		
12	„ „ 7 „ „ „ ...		1,296	+ 32
13	„ „ 5 „ „ „ ...	1,240		
14	„ „ no „ „ „ ...			
15	„ „ 5 „ „ „ ...	1,292		
16	„ „ 3 „ „ „ ...		1,252	− 46
17	„ „ 5 „ „ „ ...	1,304		
18	„ „ 7 „ „ „ ...		980	− 152
19	„ „ 5 „ „ „ ...	960		
20	„ „ no „ „ „ ...			
21	„ „ 5 „ „ „ ...	1,868		
22	„ „ 3 „ „ „ ...		1,612	+ 10
23	„ „ 5 „ „ „ ...	1,336		
24	„ „ 7 „ „ „ ...		1,444	+ 112
25	„ „ 5 „ „ „ ...	1,328		
26	„ „ 3 „ „ „ ...		1,272	− 42
27	„ „ 5 „ „ „ ...	1,300		
28	„ „ 7 „ „ „ ...		1,396	+ 124
29	„ „ 5 „ „ „ ...	1,244		

Each plot ¼ acre. Sown 5th May, 1928. Harvested 24th August, 1928.
2′ 6″ ridges. Bullock and hand cultivation.

Increase (+) or decrease (−) of 5 plots with 3 lines of gero compared with those with 5 lines.

− 230
− 18
− 46
+ 10
− 42

Average − 65±100·5 lb. per acre.

Increase (+) or decrease (−) of 5 plots with 7 lines gero compared with those with 3 lines.

− 138
+ 32
− 152
+ 112
+ 124

Average − 4·5±100·5 lb. per acre.

Root—mean—square—difference between pairs of neighbouring controls = 225·6.
Cost of cultivation in man-days per acre = 23·7.

TABLE No. 13.

Cost of Main Crops in Man-days per acre.

Crop.	Preparation.	Planting.	Cultivation.	Harvesting.	Store Work.	Total M.D.P.A.
Cotton	15·7	4·4	17·2	29·6	—	66·9
Guinea-corn	13·3	2·4	18·4	7·5	—	41·6
Groundnuts	12·7	4·2	9·2	39·6	15·7	80·7
Gero	2·8	4·1	5·9	10·3	0·6	23·7
Mucuna Single Crop	12·5	4·3	25·6	16·4	—	58·7
Mucuna Interplanted	—	1·0	2·9	4·1	1·0	9·0

ANNUAL REPORT ON THE IRRIGATION FARM, KWORRE, SOKOTO, 1928.

The following officers were in charge during the year :—

Mr. J. D. Brown, B.Sc. from 1st January to 12th July.
„ A. de K. Frampton, from 13th July to 5th December.
„ J. G. Reynard, B.Sc. from 6th to 31st December.

The Kworre farm, as was explained in the Annual Report for 1927, has available at all seasons of the year by gravitation a considerable supply of water from the Shalla brook, which was impounded by the Irrigation Engineer to the Sokoto Native Administration.

2. The principal food crop of the Kworre district is swamp rice. Hitherto, controlled irrigation, except on small market gardens close to river banks has been unknown in this region. The native rice farmer plants his seed on lowlying areas adjacent to the rivers. If the early rains are favourable, then by the time the crop is well established, the rivers overflow their banks and flood the rice land, thus ensuring a good crop.

3. During the three seasons since the Government farm has been established, of which 1928 is the third, it has been subject to this flood water, so that control of water at all times of the year has not been possible. Thus work on such lines as determining the optimum or minimum quantity of water necessary for the crop has not been attempted. A scheme is now in process of execution by which it is hoped to be able to control the flood water.

4. In view of what has been said, wet-season work has been confined to the gathering of information as to the relative yielding capacity of certain indigenous and exotic varieties of rice, their growth and requirements, the response of each of them to early and late planting, to various quantities of water (up to the time when water control became impossible) and to different planting methods.

NOTES ON EXPERIMENTAL RESULTS.

Date of Planting Tests—Rice.

(See Tables Nos. 1 and 2.)

Block A1, 21b–33b. (*Table No. 1*).

		Odds that the difference is significant.
Average yield of 13 plots planted 22nd May	= 1,565·5 lb. per acre.	—
„ difference of 4 plots planted 15th „	= + 62 ± 187·8	—
„ „ 4 „ 29th „	= − 14 ± 187·8	—
„ „ 4 „ 5th June	= −440 ± 187·8	104 : 1

These results seem to indicate that early planting is advisable, the third week in May being apparently the latest successful date, at any rate for "Maliya." (A variety introduced from Ceylon).

Block A2, 21b–33b. (*Table No. 2*).

		Odds that the difference is significant.
Average yield of 13 plots planted 22nd May	= 1,520 lb. per acre.	—
„ difference of 4 plots planted 15th „	= — 34 ± 164·4	—
„ „ 4 „ 29th „	= —102 ± 164·4	3 : 1
„ „ 4 „ 5th June	= —200 ± 164·4	8 : 1

The same remarks seem to apply to "Guiana Creole" as to "Maliya."

Variety Test Rice.

(*See Table No. 3.*)

Block B1, 20b–32b.

		Odds that the difference is significant.
Average yield of 13 plots of Jatau	= 1,611·1 lb. per acre.	—
„ difference of 4 plots of G. Creole	= —236 ± 104·3	83 : 1
„ „ 4 „ Maliya	= — 46 ± 104·3	2 : 1
„ „ 4 „ Guiana 75	= —186 ± 104·3	26 : 1

The local variety shows a marked superiority, except over "Maliya."

Watering Tests.

(*Table No. 4.*)

Block A1, 1a–16b. (*Table No. 4.*)

Average yield of 10 plots under "swamp" conditions, 2,560 lb. per acre.

Average yield of 10 plots under "wet" conditions, 2,077 lb. per acre.

Average yield of 10 plots under "damp" conditions, 1,970 lb. per acre.

Guiana Creole was sown here and seems to thrive best under swamp conditions, but it must be remembered that the southern plots, where the wet and damp conditions prevailed, are on light soil, not generally accepted as good rice land.

TABLE No. 1.

RICE—DATE OF PLANTING TEST.

Block and Plot.	Date Planted.	Yields per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
A1. 21*b*	22 May	1,712	
22*a*	15 May	1,840	+ 16
b	22 May	1,936	
23*a*	29 May	2,224	+ 144
b	22 May	2,224	
24*a*	5 June	1,616	− 304
b	22 May	1,616	
25*a*	15 May	2,064	+ 208
b	22 May	2,096	
26*a*	29 May	1,616	− 384
b	22 May	1,904	
27*a*	5 June	784	− 968
b	22 May	1,600	
28*a*	15 May	1,456	+ 8
b	22 May	1,296	
29*a*	29 May	1,472	+ 32
b	22 May	1,584	
30*a*	5 June	1,456	− 56
b	22 May	1,440	
31*a*	15 May	1,136	+ 16
b	22 May	800	
32*a*	29 May	1,152	+ 152
b	22 May	1,200	
33*a*	7 June	640	− 432
b	22 May	944	

Variety sown: Maliya. Sown as above. Harvested early November.

Increase (+) or decrease (−) of Plots sown on 15th May as compared with 22nd May.

+ 16 lb. per acre.
+ 208 „ „ „
+ 8 „ „ „
+ 16 „ „ „

Average + 62 ± 187·8 lb. per acre.

Increase (+) or decrease (−) of Plots sown 29th May compared with 22nd May.

+ 144 lb. per acre.
− 384 „ „ „
+ 32 „ „ „
+ 152 „ „ „

Average − 14 ± 187·8 lb. per acre.

Increase (+) or decrease (−) of Plots sown 5th June compared with plots sown 22nd May.

− 304 lb. per acre.
− 968 „ „ „
− 56 „ „ „
− 432 „ „ „

Average − 440 ± 187·8 lb. per acre.

Root—mean—square—difference between neighbouring control plots = 375·7.

TABLE No. 2.

RICE—DATE OF PLANTING TEST.

Block and Plot.	Date Planted.	Yield per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
A2. 21*b*	22 May	1,728	
22*a*	15 May	2,112	+ 264
b	22 May	1,968	
23*a*	29 May	2,064	+ 128
b	22 May	1,904	
24*a*	5 June	1,792	− 32
b	22 May	1,744	
25*a*	15 May	1,520	− 144
b	22 May	1,584	
26*a*	29 May	1,280	− 216
b	22 May	1,408	
27*a*	5 June	1,120	− 224
b	22 May	1,280	
28*a*	15 May	1,440	− 80
b	22 May	1,760	
29*a*	29 May	1,248	− 192
b	22 May	1,120	
30*a*	5 June	1,040	− 360
b	22 May	1,680	
31*a*	15 May	1,296	− 176
b	22 May	1,264	
32*a*	29 May	1,104	− 128
b	22 May	1,200	
33*a*	5 June	976	− 184
b	22 May	1,120	

Variety:—Guiana Creole — Sown as above. Harvested early November.

Increase (+) or decrease (−) of plots sown on 15th May as compared with 22nd May.

+ 264 lb. per acre.
− 144 „ „ „
− 80 „ „ „
− 176 „ „ „

Average − 34 ± 164·4 lb. per acre.

Increase (+) or decrease (−) of plots sown on 15th May as compared with 29th May.

+ 128 lb. per acre.
− 216 „ „ „
− 192 „ „ „
− 128 „ „ „

Average − 102 ± 164·4 lb. per acre.

Increase (+) or decrease (−) of plots sown on 15th May as compared with 5th June.

− 32 lb. per acre.
− 224 „ „ „
− 360 „ „ „
+ 184 „ „ „

Average − 200± 164·4 lb. per acre.

Root—mean—square—difference between neighbouring control plots = 328·8.

TABLE No. 3.

RICE—VARIETY TEST.

Block and Plot.	Variety.	Yield per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
B1. 20*b*	Jatau	1,600	
21*a*	Guiana Creole ...	1,680	+ 0
b	Jatau	1,760	
22*a*	Maliya	2,160	+ 360
b	Jatau	1,840	
23*a*	Guiana 75	1,792	+ 8
b	Jatau	1,728	
24*a*	Guiana Creole ..	1,376	− 304
b	Jatau	1,632	
25*a*	Maliya	1,616	− 168
b	Jatau	1,936	
26*a*	Guiana 75	1,440	− 424
b	Jatau	1,792	
27*a*	Guiana Creole ...	1,360	− 320
b	Jatau	1,568	
28*a*	Maliya	1,472	− 96
b	Jatau	1,568	
29*a*	Guiana 75	1,152	− 360
b	Jatau	1,456	
30*a*	Guiana Creole ...	1,216	− 320
b	Jatau	1,616	
31*a*	Maliya	1,264	− 280
b	Jatau	1,472	
32*a*	Guiana 75	1,216	− 8
b	Jatau	976	

Varieties as above. Sown 4th June, 1928. Harvested early November.

Increase (+) or decrease (−) of yields of G. Creole as compared with Jatau.

+ 0
− 304
− 320
− 320

Average − 236 ± 104·3 lb. per acre.

Increase (+) or decrease (−) of yields of Maliya as compared with Jatau.

+ 360
− 168
− 96
− 280

Average − 46 ± 104·3 lb. per acre.

Increase (+) or decrease (−) of yields of Guiana 75 as compared with Jatau.

+ 8
− 424
− 360
− 8

Average − 186 ± 104·3 lb. per acre.

Root—mean—square—difference between neighbouring control plots 208·6.

TABLE No. 4.

RICE—WATERING EXPERIMENT.

Block and Plot.	Treatment.	Yield per acre.	Average per acre.
A1. 1*a*	Swamp condition.	2,832	2,560
b		2,640	
2*a*		2,704	
b		2,576	
3*a*		2,464	
b		2,560	
4*a*		2,768	
b		2,656	
6*a*		2,272	
b		2,128	
7*a*	Wet conditions.	1,728	2,077
b		1,776	
8*a*		1,728	
b		2,224	
9*a*		2,496	
b		2,576	
10*a*		1,776	
b		2,096	
11*a*		2,208	
b		2,160	
12*a*	Damp conditions.	1,760	1,970
b		2,064	
13*a*		2,320	
b		2,432	
14*a*		2,000	
b		1,952	
15*a*		2,336	
b		1,840	
16*a*		1,632	
b		1,360	

Variety sown:—GUIANA CREOLE.

Each Plot $\frac{1}{16}$ acre. Sown 15th June, 1928. Harvested early November.

Average yield of 10 plots "Swamp" = 2,560 lb. per acre.

" " " " "Wet" = 2,077 " " "

" " " " "Damp" = 1,970 " " "

ANNUAL REPORT YANDEV PLANTATION, 1928 (BENUE PROVINCE).

The following officers were in charge during the year :—

Mr. I. E. James, B.SC., from 1st January to 15th June.

Mr. J. F. Ward, M.A., from 18th August to 18th December.

Mr. I. E. James, B.SC., from 23rd June to 31st December.

Experiments dealing with the main Munshi crops have now been carried out on the plantation for three years and some useful results have already been obtained.

In spite of the rather abnormally wet season, in which the rain was most unevenly distributed, the yields of most of the crops were superior to those obtained in 1927, and this increase has helped to make the experiments of greater value.

Introduction to Experimental Results.

The forty acres of land set apart for the trial of a four years' rotation (A) entered a second season of cropping. Ten acres of bush land were taken in for testing a second rotation (B) as it appears that the original rotation (A) may become too exhaustive.

The two rotations are set out below :—

	Rotation A.	Rotation B.
1st Year.	Yams interplanted with beans.	Yams interplanted with cotton.
2nd Year.	Millet and Guinea-corn.	Millet and Guinea-corn.
3rd Year.	Green Manure followed by Cotton.	Benniseed followed by Green Manure.
4th Year.	Benniseed followed by Green Manure.	Green Manure.

"Variety Trials" and "Times of Planting" experiments are being continued, and the results at present obtained suggest that earlier planting of most crops may profitably be carried out.

Investigations into the cultural operations are being furthered in order to substantiate the native practices or to introduce improved methods. The residual value and costings of various crops are also being examined.

Yams—Times of Planting.

(*See* Table No. 1).

	Yield in lb. per acre.	Odds difference is significant.
Average yield of plots planted 17th, February...	10,057·2	—
Average difference 5 plots planted 16th, April	− 3,342·4±546·8	∝ : 1
Average difference 4 plots planted 18th, June	− 8,251·5±611·3	∞ : 1

This experiment was originally laid down to find what amount of damage may be caused by the yam beetle, (*Heteroligus claudius Klug*), to yams planted at different dates. It is now realised that early-planted yams, in an experiment of this kind, act as a trap crop: thus minimizing the attack on the later-planted yams, and so vitiating the results of the experiment. It will be observed that in this particular season, at any rate, the time of planting *per se* far outweighed any untoward effects of the beetle.

This is a good example of the complexity of the factors affecting accurate experimentation.

Yams.—Staking *versus* Non-Staking.

(*See* Table No. 2).

	Yield in lb. per acre.	Odds difference is significant.
Average yield 5 plots staked	10,763·2	—
Average difference 4 plots non-staked ...	− 505·7±335	14 : 1

It is indicative that staking results in heavier yields. Short poles were used for the second season to stake the yams, but the cost of staking more than counter-balanced any increased return from the yams.

The contrast between the above results and those previously obtained at other stations must be attributed, in all probability to differences in the local varieties of yams under experiment.

Yams—Depth of Planting.

(*See* Table No. 3).

	Yield in lb. per acre.	Odds difference is significant.
Average yield 10 plots planted 4 inches deep	7,523	—
Average difference 5 plots planted 6 inches deep	− 1,566·2 ± 1,077·3	14 : 1
Average difference 4 plots planted 9 inches deep	− 1,561·7 ± 1,204·5	8 : 1

The results of this experiment suggest that deeper planting may cause lower yields. The soil of these plots varies from about one foot of stony gravel soil lying on a hard stony subsoil to a sandy loam passing gradually into a brown sandy subsoil, into which the yams could penetrate.

The infestation of the yam beetle was irregular and no indications were obtained that the depth of planting yams effected the intensity of the attack.

Benniseed—Method of Harvesting

(*See* Table No. 4).

	Yield in lb. per acre.	Odds difference is significant.
Average yield 5 plots harvested Munshi method	355·6	—
Average difference 4 plots stooked ...	— 24·2 ± 23	5 : 1

The benniseed was sown on six foot ridges and harvested at the end of July under ideal conditions. There was little difference in yield between the two methods of harvesting. "Stookings benniseed is a much less costly operation than the native method of erecting drying stands and tying the benniseed into small bundle.' The total cost of cultivation in man-days per acre was as follows:

Munshi method	91½ M.D. per acre.
Stooking method	57½ M.D. per acre.

Benniseed—Method of Preparation and of Sowing.

(*See* Table No. 5).

	Yield in lb. per acre.	Odds difference is significant.
Average yield 10 plots on 3 feet ridges	266	—
Average difference 9 plots broadcasted	+ 6·6 ± 7·2	4 : 1

The native custom is to sow the benniseed broadcast on land previously weeded and levelled. This method has been tested against dibbling in the seed on three foot ridges. The benniseed was weeded once and the two treatments gave almost identical yields. The native methods of harvesting were employed.

The total cost of cultivation in Man-days per acre was as follows:

On three foot ridges	95 M.D. per acre.
Broadcasted	78 M.D. per acre.

Benniseed—Size of Ridges.
(*See* Table No. 6).

	Yield in lb. per acre.	Odds difference is significant.
Average yield 5 plots on 6 feet ridges ...	254·4	—
Average difference 4 plots on 3 feet ridges	+ 22·75 ± 19·6	6 : 1

The results suggest that better yields may be obtained off three foot ridges. The benniseed was sown in three rows on six foot ridges and in two rows on the three foot ridges. Only with the latter method of cultivation did the plants form a continuous cover.

Groundnuts—Times of Planting.
(*See* Table No. 7).

	Yield of dried undecorticated nuts in lb. per acre.	Odds difference is significant.
Average yield 10 plots sown 8th May ...	559·8	—
Average difference 5 plots sown 16th April	+ 185 ± 43·6	33,300 : 1
Average difference 4 plots sown 2nd April	+ 204 ± 48·8	33,300 : 1

It is significant that lower yields are obtained the later the groundnuts are planted after the beginning of April. Germination was fair on all plots, but was delayed on plots sown on 16th April, owing to the dry weather then experienced. Excellent growth was made and the ground became completely covered by the plants.

Slight symptoms of "Bunching" occurred in July, but no difference in the susceptibility of the plants to disease due to time of planting could be observed.

On all plots a high proportion of shrivelled nuts occurred.

Groundnuts—Variety Trial.
(*See* Table No. 8).

	Yield of dried undecorticated nuts in lb. per acre.	Odds difference is significant.
Average yield 5 plots Munshi	404·4	—
Average difference 4 plots, Zaria ...	+ 82·5 ± 125·9	3 : 1

Both varieties were planted at the beginning of April but had to be supplied owing to poor germination. Much "Bunching" occurred, especially on the plants on the lower parts of the plots where a heavy type of soil is situated. Both varieties suffered from the dry weather in July and August and produced a high proportion of shrivelled nuts.

Maize—Variety Test.

(*See* Table No. 9).

	Yield of grain in lb. per acre.	Odds difference is significant.
Average yield 10 plots, Munshi	444·4	—
Average difference 6 plots, Lagos White	— 95·5 ± 45·7	43 : 1
Average difference 3 plots, Hickory King	— 87·4 ± 60·5	13 : 1

Lagos White gave significantly lower yields than the local maize. The results also convey an indication that Hickory King does not yield as well as Munshi maize. The crop was planted at the end of April, and receiving the full benefits of the May rains, germinated quickly and commenced to grow well but deteriorated during the later stages. The germination of Lagos White and Hickory King was low.

Gero and Guinea-corn —Times of Planting Guinea-corn Through Gero.

(*See* Table No. 10).

	Yield of gero and guinea-corn in lb. per acre (grain).	Odds difference is significant.
Average yield 10 plots guinea-corn planted 6 weeks after gero	378·5	—
Average difference 5 plots guinea-corn 11 weeks after gero	—195·7±58·4	3,000 : 1
Average difference 4 plots guinea-corn 13½ weeks after gero	—194·5±65·3	740 : 1

The gero was sown late, germinated badly, and produced a very low yield. The guinea-corn was sown in between the gero on the side of the ridge and was earthed up from time to time.

Early planting of guinea-corn through gero results in definitely heavier yields. The corn sown eleven and thirteen and a half weeks after gero germinated badly, and was poor all through the season. The yield was much reduced by parasitization of the guinea-corn by striga senegalensis.

Guinea-corn—Times of Planting

(*See* Table No. 11).

	Yield in lb. per acre (grain.)	Odds difference is significant
Average yield 10 plots sown 29th May	425	—
Average difference 5 plots sown 4 weeks later	—104·6± 90·6	6 : 1
Average difference 4 plots sown 6½ weeks later	—270 ± 101·2	300 : 1

In spite of the fact that unsuitable land was used, the results definitely show that late planting results in low returns. The guinea-corn sown in May germinated badly and became severely parasitized by striga senegalensis. The guinea-corn sown four, and six and a half weeks later, germinated much better and was much freer from parasitization. The July sown guinea-corn had not matured before the dry weather set in and hence produced a fair proportion of semi-blind ears.

Cotton—Variety Trial.

(*See* Table No. 12).

	Yield of seed cotton in lb. per acre.	Odds difference is significant.
Average yield 10 plots Munshi	120	—
Average difference 5 plots Ishan "A" ...	+ 87·7 ± 7·0	∝ : 1
Average difference 4 plots Allen ...	− 26·7 ± 7·8	5,000 : 1

The results of this experiment show that during the past season Ishan 'A' gave definitely heavier yields of seed cotton than either Munshi or Allen. It appears to be fairly definite that Allen, on this plantation, suffers the most severely of the three varieties from the depredations of the cotton stainer. Munshi and Ishan 'A' are more damaged by stainer infestation when grown with Allen than when grown alone. The early growth of all the plants was poor owing to the dry conditions in July and August. Munshi cotton was considerably later in producing flowers and bolls than either Allen or Ishan 'A'. Ishan cotton produced a greater crop of flowers but was vegetatively less robust, and appeared to suffer more from the dry weather than Munshi. In comparison with Munshi and Allen cotton, a very large proportion of the Ishan 'A' lint was stained and dirty.

Munshi Cotton—Times of Planting.

(*See* Table No. 13).

	Yield of seed cotton in lb. per acre.	Odds difference is significant.
Average yield 10 plots planted 3rd July	253	—
Average difference 5 plots, 16th July ...	− 71·7 ± 15·4	33,300 : 1
Average difference 4 plots, 2nd August	−118·7 ± 17·3	∞ : 1

The results of this experiment show that early planting of cotton begets good yields whereas later planting produces much lower yields.

The cotton germinated badly on account of the dry weather of July and August, but, once established, it suffered no serious check from pests and diseases and grew away steadily.

The proportion of dirty cotton to clean is low, especially in the yields of the later plantings.

Munshi Cotton through Yams—Times of Planting Yams.

(*See* Table No. 14).

	Yield of seed cotton in lb. per acre.	Odds difference is significant.
Average yield 10 plots after February planted yams	42	—
Average difference 5 plots after April planted yams	+ 29·3±4·7	33,300 : 1
Average difference 4 plots after June planted yams	+175·1±5·3	∝ : 1

Cotton planted at the beginning of July, through early planted yams, has great difficulty in becoming established owing to the smothering effects of the yam vines. Greatly superior yields are obtained from cotton grown through late planted yams. As has already been seen in Table No. 1, however, the yield from the late planted yams is relatively less.

The plants only suffered slightly from pests and diseases and produced a very high proportion of clean seed cotton.

Guinea-corn through Gero—Test Crops for Residual Value of Green Manures.

(*See* Table No. 15).

	Yield of gero and guinea-corn in lb. per acre (grain).	Odds difference is significant.
Average yield 10 plots after Mucuna ...	871·1	—
Average difference 5 plots after Mucuna followed by Cowpeas	−238·3±94·5	160 : 1
Average difference 4 plots after Pigeon Peas	− 66 ±105·1	3 : 1

The object of this experiment was to find out if an edible leguminous crop, or a combination of such crops, could be found to give as good a residual value as mucuna. Mucuna followed by cow-peas, and pigeon peas were tested against mucuna alone. Turning in mucuna in August, and sowing with cow-peas, gave definitely inferior results. Gero and guinea-corn were planted as test crops. The gero produced a fair yield but was not uniform. The yield of guinea-corn was good throughout the block.

TABLE No. 1.

YAMS—TIMES OF PLANTING.

No. of Plot.	Treatment.	Yield in lb. per acre.	Increase (+) or decrease (−) compared with meean of adjacent controls.	
Block C7.				
Plot 1	17.2.28	7,824		
2	16.4.28	5,198	−3,607	
3	17.2.28	9,786		
4	18.6.28	2,572		−6,861
5	17.2.28	9,080		
6	16.4.28	6,746	−2,850	
7	17.2.28	10,112		
8	18.6.28	2,192		−7,581
9	17.2.28	9,434		
10	16.4.28	5,534	−4,989	
11	17.2.28	11,612		
12	18.6.28	812		−10,871
13	17.2.28	11,754		
14	16.4.28	8,284	−3,342	
15	17.2.28	11,498		
16	18.6.28	1,210		−8,699
17	17.2.28	10,320		
18	16.4.28	7,812	−1,924	
19	17.2.28	9,152		

Each plot ¼ acre. Ridges 6 feet apart. Single sets 2 feet apart.

Harvested 3rd December, 1928.

Average yield of 10 control plots ... ... 10,057·2 lb. per acre.

Average decrease of 5 plots planted 16th, April ... ... −3,342·4 ± 546·8.

„ „ „ 4 „ „ 18th, June ... ... −8,251·5 ± 611·3.

Root-mean-square—difference between neighbouring control plots 1,222·6 lb. per acre.

Average weight per 1,000 tubers.

Yams planted 17th February, 1928	...	...	3,506 lb.
„ „ 16th April, 1928	...	...	3,195 lb.
„ „ 18th June, 1928	...	...	1,827 lb.

Average percentage of seed-yams to total yield.

Yams planted 17th February, 1928	...	...	10·6 *per cent.*
„ „ 16th April, 1928	...	...	17·5 „ „
„ „ 18th June, 1928	...	...	66·3 „ „

Average percentage of tubers damaged by the yam beetle, Heteroligus claudius.

Yams planted 17th February, 1928	...	...	14·1 *per cent.*
„ „ 16th April, 1928	...	...	3·5 „ „
„ „ 18th June, 1928	...	...	0·9 „ „

TABLE No. 2.

YAMS—STAKING *versus* NON-STAKING.

No. of Plot.	Treatment.	Yield in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block C1.			
Plot 11	Staking	10,888	
12	Non-staking	9,388	−1,327
13	Staking	10,542	
14	Non-staking	9,826	−1,181
15	Staking	11,472	
16	Non-staking ...	11,808	+ 724
17	Staking	10,696	
18	Non-staking ...	10,228	− 239
19	Staking	10,238	
20	Staking	10,424	Non-experimental.

Each Plot $\frac{1}{4}$ acre. Ridges 6 feet apart. Single sets 2 feet apart.

Planted; 20th, April. Staked; 30th–31st May, 1928.

Harvested; 11th January, 1929.

Average yield of 5 plots, staked, (controls) 10,763·2 lb. per acre.

Average decrease of 4 plots non-staked 505·7 ± 335.

Root—mean square difference between neighbouring control plots 670 lb. per acre.

Average weight per 1,000 tubers.

Staked	4,701 lb.
Non-staked	4,731 lb.

TABLE No. 3.

YAMS—DEPTH OF PLANTING.

No. of Plot.	Treatment.	Yield in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block B2.			
Plot 1	4 inches	9,822	
2	6 „	7,352	− 1,486
3	4 „	7,854	
4	9 „	7,496	− 241
5	4 „	6,656	
6	6 „	4,890	− 842
7	4 „	4,808	
8	9 „	4,262	− 924
9	4 „	5,564	
10	6 „	5,368	− 1,224
11	4 „	7,620	
12	9 „	5,730	− 1,986
13	4 „	7,812	
14	6 „	4,754	− 4,665
15	4 „	11,026	
16	9 „	4,968	− 3,578
17	4 „	6,066	
18	6 „	7,420	+ 386
19	4 „	8,002	
20	4 „	8,416	Non-experimental.

Each plot ¼ acre. Ridges 6 feet apart. Single sets 2 feet apart.

Planted: 18th April, 1928. Harvested: 14th January, 1929.

Average yield of 10 control plots 7,523 lb. per acre.

Average decrease of 5 plots, planted at 6 inches deep −1,566·2 ± 1,077·3.

„ „ „ 4 „ „ „ 9 „ „ −1,561·7 ± 1,204·5.

Root-mean-square difference between neighbouring control plots 2,409 lb. per acre.

Average weight per 1,000 tubers.

Yams planted	4	inches	deep	4,018 lb.
„ „	6	„	„	4,058 lb.
„ „	9	„	„	4,032 lb.

Average percentage of seed—yams to total yield.

Yams planted	4	inches	deep	5·4 *per cent.*
„ „	6	„	„	6·4 „ „
„ „	9	„	„	5.1 „ „

Average percentage of tubers damaged by the yam beetle, Heteroligus claudius.

Yams planted	4	inches	deep	4·1 *per cent.*
„ „	6	„	„	3·6 „ „
„ „	9	„	„	3·7 „ „

TABLE No. 4.

BENNISEED—METHOD OF HARVESTING.

No. of Plot.	Treatment.	Yield in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block B8.			
Plot 1	Munshi harvesting method	304	
2	Stooking method	332	− 16
3	Munshi harvesting method	392	
4	Stooking method	360	− 20
5	Munshi harvesting method	368	
6	Stooking method	364	+ 2
7	Munshi harvesting method	356	
8	Stooking method	294	− 63
9	Munshi harvesting method	358	
10	Munshi harvesting method	258	Non-experimental.

Each plot $\frac{1}{4}$ acre. Ridges 6 feet apart. Benniseed grown in three rows, stands 1 foot apart and staggered, 3–4 plants per stand.

Sown, 30th April, 1928. Harvested, 31st July, 1928.

Average yield of 5 control plots 355·6 lb. per acre.

Average decrease of 4 plots, stooked $-24{\cdot}2 \pm 23$.

Root—mean—square—difference between neighbouring control plots 46 lb. per acre.

TABLE No. 5.

BENNISEED—METHOD OF PREPARATION AND OF SOWING.

No. of Plot.	Treatment.	Yield in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block C3.			
Plot 1	Ridges	284	
2	Broadcast	286	+ 21
3	Ridges	246	
4	Broadcast	332	+ 79
5	Ridges	260	
6	Broadcast	268	+ 15
7	Ridges	246	
8	Broadcast	266	+ 9
9	Ridges	268	
10	Broadcast	284	+ 33
11	Ridges	234	
12	Broadcast	286	+ 31
13	Ridges	276	
14	Broadcast	238	− 36
15	Ridges	272	
16	Broadcast	246	− 42
17	Ridges	304	
18	Broadcast	242	− 50
19	Ridges	280	
20	Ridges	318	

Each Plot $\frac{1}{4}$ acre. Ridges 3 feet apart. Sown in two rows, stands 1 foot apart and staggered, 3–4 plants per stand.

Broadcast on levelled land.

Sown, 26th April, 1928. Once weeded, 23rd May, 1928.

Harvested; broadcast, 25th July, 1928. Ridges, 27th July, 1928.

Average yield of 10 control plots, 266 lb. per acre.

Average increase of 9 plots broadcast $+6{\cdot}6 \pm 7{\cdot}2$.

Root- mean- square—difference between neighbouring control plots 21·6 lb. per acre.

TABLE No. 6.

BENNISEED—SIZE OF RIDGES.

No. of Plot.	Treatment.	Yield in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block C4.			
Plot 1	Six feet ridges ...	222	
2	Three feet ridges ...	256	+ 24
3	Six feet ridges ...	242	
4	Three feet ridges ...	286	+ 20
5	Six feet ridges ...	290	
6	Three feet ridges ...	290	+ 44
7	Six feet ridges ...	242	
8	Three feet ridges ...	282	+ 23
9	Six feet ridges ...	276	
10	" " ...	296	Non-experimental.

Each plot $\frac{1}{4}$ acre. Three rows on 6 feet ridges. Stands 1 foot apart, Two rows on 3 feet ridges. 3–4 plants per stand.

Sown, 2nd May, 1928. Harvested, 2nd August, 1928.

Average yield of 5 control plots 254·4 lb. per acre.

Average increase of 4 plots, on 3 feet ridges $+22{\cdot}75 \pm 19{\cdot}6$.

Root mean-square difference between neighbouring control plots 39·2 lb. per acre.

TABLE No. 7.

Groundnuts—Times of Planting.

No. of Plot.	Treatment.	Yield in lb. per acre undecorticated nuts.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block C 9.			
Plot 1	8/5/28	462	
2	16/4/28	380	− 93
3	8/5/28	484	
4	2/4/28	972	+ 484
5	8/5/28	492	
6	16/4/28	1,112	+ 661
7	8/5/28	410	
8	2/4/28	1,028	+ 528
9	8/5/28	590	
10	16/4/28	876	+ 244
11	8/5/28	674	
12	2/4/28	724	+ 37
13	8/5/28	700	
14	16/4/28	892	+ 197
15	8/5/28	690	
16	2/4/28	366	− 234
17	8/5/28	510	
18	16/4/28	464	− 84
19	8/5/28	586	
20	8/5/28	408	Non-experimental.

Each plot ¼ acre. Ridges 3 feet apart. Two rows, stands 2 feet apart and staggered.

Decorticated seed sown at the rate of two per hole.

Sown:—8th May, 1928. Harvested:—5th October, 1928.

16th April, 1928. 8th September, 1928.

2nd „ „ 4th „ „

Average yield of 10 control plots ... 559·8 lb. per acre.

„ increase of 5 plots planted 16th April + 185 ± 43·6.

„ „ „ 4 „ „ 2nd „ + 204 ± 48·8.

Root-mean-square-difference between neighbouring control plots. 97·6 lb. per acre.

N.B.—Much damage was done to groundnuts on plot 16 by monkeys.

TABLE No. 8.

Groundnuts—Variety Trial.

No. of plot.	Treatment.	Yield in lb. per acre undecorticated nuts.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block B 5.			
Plot 11	Munshi	258	
12	Zaria	346	+ 8
13	Munshi	418	
14	Zaria	498	+ 186
15	Munshi	206	
16	Zaria	300	− 114
17	Munshi	620	
18	Zaria	820	+ 250
19	Munshi	520	
20	Munshi	612	Non-experimental.

Each plot $\frac{1}{4}$ acre. Ridges 6 feet apart. Two rows, stands 2 feet apart and staggered.

Decorticated seed sown at the rate of two per hole.

Sown 4th April, 1928. Harvested 5th September, 1928.

Average yield of 5 control plots ... 404·4 lb. per acre.

„ increase of 4 plots Zaria groundnuts + 82·5 ± 125·9.

Root—mean—square—difference between neighbouring control plots 251·8 lb. per acre.

Germination Counts.

Munshi ... ... 26·0% average stand.

Zaria ... ... 31·7% „ „

TABLE No. 9.

Maize—Variety Trial.

No. of Plot.	Treatment.	Yield in lb. per acre grain.	Increase (+) or decrease (−) compared with mean of adjacent controls.	
Block C 8.				
Plot 1	Munshi	302·4		
2	Lagos White	244·8	− 136·8	
3	Munshi	460·8		
4	Hickory King	315·6		− 118·2
5	Munshi	406·8		
6	Lagos White	370·0	− 63·8	
7	Munshi	460·8		
8	Lagos White	542·8	+ 13	
9	Munshi	598·8		
10	Lagos White	446·4	− 190·8	
11	Munshi	675·6		
12	Hickory King	524·0		− 68
13	Munshi	508·4		
14	Lagos White	207·6	− 240·2	
15	Munshi	387·2		
16	Hickory King	308·4		− 76
17	Munshi	381·6		
18	Lagos White	365·2	+ 43·8	
19	Munshi	261·2		
20	Munshi	106·8		

Each plot $\frac{1}{4}$ acre. Ridges 6 feet apart. Two rows, stands 2 feet apart and staggered, two plants per stand.

Sown 25th April, 1928. Harvested Munshi, 28th July, and 13th August. Lagos White and Hickory King, 13th August and 4th September.

Average yield of 10 control plots ... 444·4 lb. per acre.

„ decrease of 6 plots Lagos White − 95·5 ± 45·7.

„ „ „ 3 „ Hickory King − 87·4 ± 60·5.

Root-mean-square-difference between neighbouring control plots 112 lb. per acre.

Germination Counts.

Munshi	63·4%	average stand.
Lagos White	41·6%	„ „
Hickory King	34·2%	„ „

TABLE No. 10.

Gero and Guinea-corn —Times of Planting Guinea-corn through Gero.

No. of Plot.	Treatment.	Yield in lb./ Acre of Grain. Gero.	Guinea-corn.	Total.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block A 2.					
Plot 1	6 Weeks after ...	30	786	816	
2	11 Weeks after ...	20	222	242	— 440·5
3	6 Weeks after ...	51	498	549	
4	13½ Weeks after ...	59	224	283	— 234
5	6 Weeks after ...	47	438	485	
6	11 Weeks after ...	73	252	325	— 66
7	6 Weeks after ...	13	284	297	
8	13½ Weeks after ...	68	68	136	— 130·5
9	6 Weeks after ...	50	186	236	
10	11 Weeks after ...	42	80	122	— 125
11	6 Weeks after ...	62	196	258	
12	13½ Weeks after ...	26	56	82	— 239
13	6 Weeks after ...	56	328	384	
14	11 Weeks after ...	44	66	110	— 242
15	6 Weeks after ...	64	256	320	
16	13½ Weeks after ...	34	48	82	— 175
17	6 Weeks after ...	26	168	194	
18	11 Weeks after ...	16	100	116	— 105
19	6 Weeks after ...	32	216	248	
20	6 Weeks after ..	46	...	...	Non-experimental.

Each plot ¼ acre. Ridges 6 ft. apart. Gero; single row, stands 4 ft. apart. Guinea-corn; single row on side of ridge, stands 2 ft. apart.

Gero; sown 10th April. Harvested 12th and 25th July, 1928.

Guinea-corn sown 24th May. Harvested 10th December, 1928.

26th June. „ 13th December, 1928.

14th July. „ 15th December, 1928.

Average yield of 10 control plots, 378·5 lb. combined grain per acre.

Average decrease of 5 plots sown 11 weeks after gero — 195·7±58·4.

Average decrease of 4 plots sown 13½ weeks — 194·5±65·3.

Root mean-square—difference between neighbouring control plots, 130·6 per acre.

Average percentage of grain to ear.

Guinea-corn sown:—24th May, 1928 54.8%

26th June, „ 42·2%

14th July, „ 40·7%

TABLE No. 11.

Guinea-corn—Times of Planting.

No. of Plot.	Treatment.	Yield in lb./ acre of grain.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block A 9.			
Plot 1	29/5/28	276	
2	26/6/28	290	+ 25
3	29/5/28	254	
4	14/7/28	128	— 136
5	29/5/28	274	
6	26/6/28	262	— 188
7	29/5/28	626	
8	14/7/28	186	— 306
9	29/5/28	358	
10	26/6/28	328	— 151
11	29/5/28	600	
12	14/7/28	230	— 329
13	29/5/28	518	
14	26/6/28	416	— 125
15	29/5/28	564	
16	14/7/28	248	— 310
17	29/5/28	552	
18	26/6/28	306	— 84
19	29/5/28	228	
20	Non-experimental.		

Each plot $\frac{1}{4}$ acre. Ridges 6 ft. apart. Two rows, stands 1 ft. apart and staggered.

Sown:—29th May, 1928. Harvested:—11th December, 1928.
26th June, „ 13th December, „
14th July, „ 15th December, „

Average percentage of grain to ear.

Sown:—29th May, 1928 60·0%
26th June, „ 55·1%
14th July, „ 50·8%

Average yield of 10 control plots, 425 lb. per acre.

Average decrease of 5 plots sown 26th, June — 104·6±90·6.

Average decrease of 4 plots sown 14th, July — 270±101·2.

Root—mean—square—difference between neighbouring control plots, 202·5 lb. per acre.

TABLE No. 12.

Cotton—Variety Trial.

No. of Plot.	Treatment.	Yield in lb./ acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block B 1.			
Plot 1	Munshi	141	
2	Ishan 'A'	226	+ 93·5
3	Munshi	124	
4	Allen	116	− 14
5	Munshi	136	
6	Ishan 'A'	217	+ 83·5
7	Munshi	131	
8	Allen	79	− 33·5
9	Munshi	94	
10	Ishan 'A'	166	+ 64·5
11	Munshi	109	
12	Allen	94·5	− 19
13	Munshi	118	
14	Ishan 'A'	191	+ 71·5
15	Munshi	121	
16	Allen	78	− 40·2
17	Munshi	115·5	
18	Ishan 'A'	238	+125·8
19	Munshi	109	
20	Munshi	121·5	Non-experimental.

Each plot $\frac{1}{4}$ acre. Ridges 6 ft. apart. Plants in single row.

Munshi and Ishan 'A' sown 2 ft. apart, Allen 1 ft. apart.

Sown; Munshi, 3rd July, 1928.

Ishan 'A' 4th July, 1928.

Allen, 16th July, 1928

Harvested; From 3rd December, 1928 to 21st March, 1929.

Average yield of 10 control plots 120 lb. per acre.

Average increase of 5 plots, Ishan 'A' + 87·7±7·0.

Average decrease of 4 plots, Allen − 26·7±7·8.

Root—mean—square—difference between neighbouring control plots 15·7 lb. per acre.

Average percentage of dirty cotton to total yield.

Munshi	24·1%
Ishan 'A'	41·3%
Allen	35·9%

TABLE No. 13.

Cotton—Times of Planting Munshi Cotton.

No. of Plot.	Treatment.	Yield in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block B9.			
Plot 1	3/7/28	215	
2	16/7/28	178	− 57·5
3	3/7/28	256	
4	2/8/28	118	− 141·5
5	3/7/28	263	
6	16/7/28	172	− 84
7	3/7/28	249	
8	2/8/28	154	− 125·5
9	3/7/28	310	
10	16/7/28	220	− 72·5
11	3/7/28	275	
12	2/8/28	159	− 113·5
13	3/7/28	270	
14	16/7/28	191	− 82·5
15	3/7/28	277	
16	2/8/28	154·5	− 94·5
17	3/7/28	221	
18	16/7/28	145	− 62
19	3/7/28	193	
20	3/7/28	230	Non-experimental.

Each plot $\frac{1}{4}$ acre. Ridges 6 ft. apart. Plants 2 ft. apart in one row only.
Sown; 3rd July, 1928. Harvesting commenced; 27th December.
„ 16th „ „ „ „ 27th „
„ 2nd August, 1928. „ „ 11th January.

Average yield of 10 control plots, 253 lb. per acre.
Average decrease of 5 plots sown 16th July, − 71·7 ± 15·4.
Average decrease of 4 plots sown 2nd August, − 118·7 ± 17·3.

Root—mean—square—difference between neighbouring control plots, 34·6 lb. per acre.

Average percentage of dirty cotton to total yield.

Cotton planted 3rd July, 1928, 15·8%.
Cotton planted 16th July, 1928, 12·7%.
Cotton planted 2nd August, 1928, 8·2%.

TABLE No. 14.

Munshi Cotton through Yams—Times of Planting Yams.

No. of Plot.	Treatment.	Yield of seed cotton in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.	
Block C7.	through			
Plot 1	Yams planted 17/2/28	57·5		
2	do. do. 16/4/28	94·5	+ 45·2	
3	do. do. 17/2/28	41		
4	do. do. 18/6/28	172		+ 129
5	do. do. 17/2/28	45		
6	do. do. 16/4/28	46	+ 6	
7	do. do. 17/2/28	35		
8	do. do. 18/6/28	164		+ 130·5
9	do. do. 17/2/28	32		
10	do. do. 16/4/28	63·5	+ 25·5	
11	do. do. 17/2/28	44		
12	do. do. 18/6/28	252		+ 205·5
13	do. do. 17/2/28	49		
14	do. do. 16/4/28	93	+ 52	
15	do. do. 17/2/28	33		
16	do. do. 18/6/28	269		+ 235·5
17	do. do. 17/2/28	34		
18	do. do. 16/4/28	59	+ 18	
19	do. do. 17/2/28	48		
20	do. do. 17/2/28	31	Non-experimental.	

Each plot $\frac{1}{4}$ acre. Ridges 6 ft. apart. Plants 2ft. apart in one row on side of ridge.

Sown 4th July, 1928. Harvested from 8th December, 1928 to 20th March, 1929.

Harvesting of control commenced from 28th December.

Average yield of 10 control plots, 42 lb. per acre.

Average increase of 5 plots through yams planted 16th April, + 29·3 ± 4·7.
Average increase of 4 plots through yams planted 18th June, + 175·1 ± 5·3.

Root--mean—square—difference between neighbouring control plots, 10·6 lb. per acre.

Average percentage of dirty cotton to total yield.

Cotton through yams planted 17th February, 1928, 7·1%.
Cotton through yams planted 16th April, 1928, 7·0%.
Cotton through yams planted 18th June, 1928, 12·1%.

TABLE No. 15.

Guinea-corn through Gero—Test Crops for Residual Value of Green Manures.

No. of Plot.	Treatment.	Gero.	Guinea-corn.	Total.	Increase (+) or decrease (—) compared with mean of adjacent controls.
Block B3.					
Plot 1	Mucuna	288	426	714	
2	Mucuna and Cow peas	182	478	660	+ 29
3	Mucuna	110	438	548	
4	Pigeon peas	254	486	740	+ 26
5	Mucuna	274	610	884	
6	Mucuna and Cow peas	248	454	702	— 284
7	Mucuna	414	674	1,088	
8	Pigeon peas	179	512	691	— 295
9	Mucuna	302	582	884	
10	Mucuna and Cow peas	112	492	604	— 396
11	Mucuna	456	660	1,116	
12	Pigeon peas	380	550	930	— 26
13	Mucuna	204	592	796	
14	Mucuna and Cow peas	212	486	698	— 131
15	Mucuua	206	656	862	
16	Pigeon peas	294	534	828	— 28·5
17	Mucuna	275	576	851	
18	Mucuna and Cow peas	46	454	500	- 409·5
19	Mucuna	236	732	968	
20	Mucuna	108	Non-experimental.		

Each plot $\frac{1}{4}$ acre. Ridges 6 ft. apart.

Gero; Single row, stands 4 ft. apart. Guinea-corn; rows on side of ridges, stands 2 ft. apart.

Gero; sown 10th April. Harvested 11th and 25th July, 1928.

Guinea-corn; sown 25th May. Harvested 12th December.

Average percentage of grain to ear.

After Mucuna ... ... 54·6%.
„ Mucuna and Cow peas 52.3%.
„ Pigeon peas ... ... 52·9%.

Average yield of 10 control plots, 871·1 lb. per acre of combined grain.

Average decrease of 5 plots after Mucuna followed Cow peas, —238·3 ± 94·5.
Average decrease of 4 plots after Pigeon peas, ... — 66·6 ± 105·1.

Root—mean—square—difference between neighbouring control plots, 210·3 lb. per acre.

TABLE No. 16.

Cost of Cultivation of Main Crops, 1928–29 Season in Man-days per acre.

Crop.	Preparation.	Sowing.	After Cultivation.	Harvest.	Miscellaneous.	Total Man-days per acre.	
Yam	36·6	14·2	30·2	46·3	0·3	127·7	
Benniseed	20·8	3·4	8·6	55·4	...	88·2	
Groundnuts	27·3	7·7	12·8	78·0	8·0	133·8	
Maize	31·5	3·5	12·6	17·9	3·7	69·2	
Bambara Groundnut.	28·7	4·7	26·9	25·3	2·7	88·3	
Gero and Guinea-corn.	18·6	6·5	28·4	15·6	3·1	72·3	
Guinea-corn	25·9	5·2	28·8	15·1	7·0	82·0	
Mucuna	26·4	2·0	2·0	...	...	30·4	91·2
Cotton	23·5	11·9	16·2	9·2	...	60·8	
Cotton thro' Yams	...	14·5	17·1	5·4	...	37·0	

Includes the cost of opening up five acres of bushland.

The total cost of preparation is debited against the yam crop.

TABLE No. 17.

COMPARISON OF COST OF PRODUCTION AND REVENUE FROM MAIN CROPS 1928–29 SEASON.

Crop.	Cost in man-days per acre.	Average yield per acre in lb.	Cost of crop in man-days per lb.	Market value per lb. (Assumed).	Calculated return per acre.	Monetary return per man-day.	Condition of Crop.
		Lb.			£ s. d.		
Yam Gross	127·7	9,396	·013	·125d.	4 18 0	9·21d.	Tubers as stored.
do. nett	127·7	7,563	·017	·125d.	3 18 9	7·40d.	do. do.
Benniseed	88·2	259	·34	·96d.	1 0 8	2·81d.	Seed.
Groundnuts	133·8	575	·23	·50d.	1 4 0	2·15d.	Undecorticated nuts.
Maize	69·2	662	·11	·30d.	15 9	2·73d.	Dried cobs.
Bambara Groundnuts ...	88·3	669	·13	·50d.	1 7 10	3·78d.	Undecorticated nuts.
Gero and Guinea-corn ...	72·3	547	·13	·44d.	1 0 1	3·33d.	Grain.
Guinea-corn	82·0	390	·21	·44d.	14 4	2·09d.	Grain.
Cotton Sole Crop	§ 60·8	174	·35	1·65d.	1 3 11	4·72d.	Seed cotton.
Cotton thro' Yams	37·0	78	·47	1·65d.	10 8	3·48d.	Seed cotton.

§ If the costs of the green manure crop are included in the costs of preparation for cotton, then these figures should be increased by fifty per cent.

The plantation labour is paid at the rate of 6d. per day.

TABLE No. 18.

MONTHLY RAINFALL—YANDEV.

Month.	1927.		1928.	
	Rainfall inches.	No. of days of rainfall.	Rainfall inches.	No. of days of rainfall.
January	·00	0	2·16	4
February	·58	1	·00	0
March	·36	1	3·72	8
April	4·14	8	4·54	6
May	10·10	12	6·77	14
June	5·79	15	12·89	19
July	4·28	18	5·58	14
August	9·63	20	3·28	12
September	7·99	16	10·73	22
October	9·67	18	9·98	16
November	1·11	1	·11	3
December	·54	1	·87	1
Totals	54·19	111	60·63	119